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The Demography, Long Bone Growth, and Pathology of a Middle Archaic Skeletal Population From Middle Tennessee: The Anderson Site (40WM9)

Bonnie C. Joerschke
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To the Graduate Council:

I am submitting herewith a thesis written by Bonnie C. Joerschke entitled "The Demography, Long Bone Growth, and Pathology of a Middle Archaic Skeletal Population From Middle Tennessee: The Anderson Site (40WM9)." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

William M. Bass, Major Professor

We have read this thesis and recommend its acceptance:

Richard Jantz, Charles H. Faulkner

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Edward H. Fuller

Accepted for the Council:

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Vice Chancellor
Graduate Studies and Research

THE DEMOGRAPHY, LONG BONE GROWTH, AND PATHOLOGY OF A MIDDLE ARCHAIC SKELETAL POPULATION FROM MIDDLE TENNESSEE: THE ANDERSON SITE (40WM9)

A Thesis
Presented for the
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Bonnie C. Joerschke

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The Anderson skeletal series was recovered by the Middle Cumberland Archaeological Society from Nashville, Tennessee. Mr. John Dowd served as the director. I appreciate the burial records, photographs, maps, and other data that he provided for this study. Ken Steverson and Bruce Lindstrom provided preliminary information on the projectile points and Emanuel Breitburg on the faunal remains. Their assistance is gratefully acknowledged.

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ABSTRACT

A biological examination of the skeletal remains from the Anderson site, 40WM9, Williamson County, Tennessee, was conducted to provide information about the nature of Middle Archaic populations from Middle Tennessee. Vital statistics were reconstructed by means of a life table assuming stable population conditions. Results of this analysis indicate a pattern of low infant/child mortality and high adult mortality. Life expectancy at birth was 23 years and the crude death rate was 43 per 1000 per annum.

The health status of the Anderson population was further inferred through investigations of long bone growth and bone pathologies. The long bone growth rates of the Anderson children were evaluated by the regression model: bone length = $b_o + b_1(\text{age}) + b_2(\log_{10}\text{age})$. Comparison of the Anderson growth rates with those of the Arikara children revealed similar rates of growth between 0.5 and 11.9 years. Comparison of adult femur length indicated that the Anderson males were the same size as males from other skeletal populations regardless of time period, geographical location, or subsistence pattern differences. Anderson females displayed the same pattern except their mean femur length was significantly smaller than that of females from Late Mississippian populations in Tennessee. This pattern contradicts the theory that stature decreased with a shift to maize agriculture.

Pathology data indicated that the most common problems which affected the Anderson people were degenerative arthritis, dental diseases, and fractures. In general, these conditions became more frequent with increasing age. Males were more frequently affected by degenerative arthritis and fractures than females.

Evidence from this study provides complementary biological information for current archaeological research in the human ecology of the Middle Archaic period in Middle Tennessee.

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CHAPTER I

INTRODUCTION

The Middle Archaic dates from approximately 6000-4000 B.C., and was a period of regional adaptation by small groups of relatively semi-sedentary hunter-gatherers who shifted settlements from along inland streams to upland areas according to the seasonal availability of local plant and animal food resources (Griffin 1967; Muller 1978). Little is known about the Middle Archaic in the Midsouth and Tennessee. In the Nashville Basin, in particular, no Middle Archaic sites have been comprehensively analyzed and reported. And, in Tennessee, in general, skeletal material is usually absent, unanalyzed, or inadequately studied at sites with Middle Archaic components (cf., Chapman 1975, 1977; Faulkner and McCollough 1973).

The first sizeable, relatively well-preserved Middle Archaic skeletal sample from Middle Tennessee was recovered in the 1980 and 1981 excavation seasons of the Anderson site, 40WM9. Located in the Nashville Basin, this site offers a rare opportunity to analyze the adaptive success of a Middle Archaic group to its particular environment. This thesis estimates the structure and physical well being of the Anderson skeletal population as it is inferred from demographic, long bone growth, and pathology data.

Analytical Background

Demographic, long bone growth, and pathology patterns have been addressed in the analyses of the few well-known Archaic skeletal series from the Southeast (e.g., Johnston 1962; Johnston and Snow 1961; Magennis 1977; Neumann 1967; Snow 1948; Sundick 1978). These studies provide the base line from which the approach taken in this study is derived.

The life table is the usual demographic model employed by contemporary physical anthropologists to determine a population's structure or to measure the biological adaptive success of a population to its environment. If the limitations of studying skeletal populations are satisfactorily addressed, this model facilitates comparisons of intra- and inter-population vital statistics.

Among the limitations that must be considered are those relating to the biases associated with the deposition and recovery of the skeletal sample and those relating to the selection of reliable skeletal ageing criteria (Palkovich 1978). In a recent study, life tables were reconstructed to determine the demographic structure of the Middle and Late Archaic skeletal series from the Eva and Cherry sites of Western Tennessee (Magennis 1977). The vital statistics from these tables showed that the samples did not represent a total population, had an under-representation of infants and an over-representation of older adults. Magennis (1977:138) attributed these demographic biases to continual shifts in settlement and subsistence by these Archaic hunter-gatherers. In general, this study forms a good base on which to develop and interpret demographic patterns at other Southeastern Archaic sites. However, endocranial suture closures were used as a secondary means of assessing adult age (Magennis 1977:51); these features are known to be unreliable adult age indicators (Singer 1953). In addition, subadult ages were estimated by the McCall and Schour (1960) American White standards for dental eruption, enamel completion, and root tip closure. Several studies have shown, however, that dental eruption may occur earlier in American Indians than in American Whites and that dental calcification rates may provide a better estimate of subadult age for Indian populations (Merchant and Ubelaker 1977; Owsley and Jantz n.d.; Ubelaker 1978). The analytical problems associated with the unreliability of these ageing criteria may significantly affect a direct comparison of the Eva and Cherry demographic parameters with those reconstructed for other Archaic populations.

Demographic parameters provide information about a given population's social structure and mortality distribution, both of which are affected by varying degrees of nutritional and disease stress, depending on the particular population. Two osteological measures of these pressures are long bone growth and pathology. Neither method has received much attention in the analyses of Southeastern Archaic skeletal samples.

Two studies of long bone growth are available for the Archaic period. Both were based on the Indian Knoll skeletal sample recovered in 1939 by Webb (1945). In one study, Johnston (1962) estimated ages for 165 infants and children up to 5.5 years using both osseous and dental ageing criteria, the latter consisting of the Schour and Massler (1941, 1944) dental eruption standards for American White children (Merchant and Ubelaker 1977). Pooled-sex growth curves were then formed by plotting dental age against the maximum diaphyseal lengths of the humerus, radius, ulna, femur, tibia and fibula. Johnston (1962) found that the growth rates of Indian Knoll children were similar to those of American White children until 2 years of age, after which the Indian children's rates decreased. In contrast, Sundick (1978), using the same dental ageing criteria and the same long bone measurements, found similar growth rates until the age of puberty between 128 Indian Knoll subadults and 82 White subadults from the European Middle Ages site at Altenerding, West Germany. The discrepancies in these studies reflect the danger of assessing long bone growth rates by unreliable dental ageing criteria and justify avoiding these studies' growth data as the standards by which to estimate nutritional and disease stress in other Archaic populations.

The study of bone pathology provides an indirect measure of the effects of disease on a given population's morbidity and mortality patterns. It is well known, however, that the absence of soft tissue often makes accurate diagnosis of a disease impossible in skeletal material. Because different diseases may produce similar lesions, the most reasonable approach is to examine broad categories of pathological activity and their age-, and in some cases sex-, specific distributions. Unfortunately, information regarding the disease patterns of Tennessee Archaic populations is rare. Magennis (1977) assessed the overall health of the large Eva and Cherry skeletal samples using generalized disease categories but did not report the results for comparative purposes. It is noteworthy, however, that diseased individuals were not given differential burial treatment at these sites (Magennis 1977).

A detailed report of pathologies is available for the nine burials recovered from the Garrett site in Middle Tennessee (McMahan n.d.). In this Middle Archaic skeletal sample, only two individuals were free from pathologies and they were both infants. Of the remaining adult burials, three exhibited traumatic lesions and three exhibited dental maladies. McMahan (n.d.:18) attributed the high frequency of pathological lesions in this group to mineral deficiencies and a rigorous lifestyle. Unfortunately, the size of this skeletal sample limits its usefulness in comparisons to other sizeable Archaic skeletal series.

Other Archaic sites with similarly small skeletal samples and disease patterns are known for both the Southeast (Sensing and Hoar 1962) and for the Midwest (Buikstra 1975; Neumann 1967). The general absence of infants and subadults in these samples suggests that they represent biased segments of an entire social group and therefore cannot be assumed to depict the disease experience of the actual populations from which they were derived. Because of these sampling biases, the Indian Knoll skeletal series is the usual reference for disease patterns in Southeastern Archaic populations. As noted by Snow (1948), the ailments in this large skeletal population ranged from the more common cases of arthritis, dental abscesses, and fractures to the less frequent cases of possible syphilis and dietary deficiency. Also noteworthy were signs of warfare as inferred from dismembered bodies in graves and from skeletal lesions caused by inflicted projectile points (Snow 1948:523-530). Although the Indian Knoll data provide an excellent reference for a broad interpretation of pathologies in other Archaic skeletal samples, they are of limited usefulness in a more detailed comparative analysis because Snow failed to provide the age distribution of individuals affected by the various pathologies.

Research Objectives

The above review illustrates the current understanding of Archaic skeletal populations in the Southeast. Methodological and analytical problems limit the usefulness of previous demographic and long bone growth studies; sample size and reporting problems limit comparisons of the pathology studies. The purpose of this thesis is to provide the first comprehensive skeletal analysis of a Middle Archaic skeletal sample in Middle Tennessee. This was made possible by the good state of preservation and the representation of individuals within all age groups in the Anderson skeletal sample.

Three topics are investigated in order to assess the biological adaptive success of the Anderson population. First, a life table is reconstructed to obtain the vital statistics of mortality, survivorship, age-specific probability of death and life expectancy at birth. The general effect of nutritional and disease stress on the morbidity and mortality experience of these people is then inferred through an investigation of long bone growth and pathology patterns. Long bone growth rates for children 0.5 to 11.9 years of age are analyzed by regressing dental age (as obtained from dental calcification rates) against the diaphyseal lengths of four long bones. The pathology patterns of the Anderson series are investigated using broad disease categories which reflect ailments with the potential to incapacitate and restrict an individual from effective participation in social activities. The age- and/or sex-specific distributions of these diseases are presented to assess the overall health status of the Anderson population.

In summary, the objectives of the present study are to:

1. provide the first comprehensive skeletal analysis for the Middle Archaic period in Middle Tennessee.
2. provide comparative demographic, long bone growth, and pathology data for future skeletal studies in the Southeast.
3. provide biological data to complement the archaeological remains currently used in models of human ecology for Tennessee.

CHAPTER II

ARCHAEOLOGY

Evidence from recent paleobotanical and paleontological research in the Midsouth demonstrates that distinct variations in regional and/or local environmental conditions occurred during the warm, arid Hypsithermal Interval of the Middle Archaic period (Delcourt 1979; Delcourt and Delcourt 1979; Klippel and Parmalee 1982). It has been proposed that Middle Archaic populations living in the Nashville Basin adapted to these environmental conditions by remaining at a semi-permanent site during most of the year and by procuring a broad range of local plant and animal food resources (Hofman n.d.). The recent recovery of the Anderson skeletal series provides the first opportunity to interpret the biological adaptive success of a Middle Archaic population to such cultural-environmental conditions in Middle Tennessee. Before the skeletal biology of the Anderson people can be investigated, the nature of the site and its function in the Middle Archaic period of the region must be understood. The following is a description of the site, its place in the cultural chronology of Tennessee, and its length of occupation. The current paleoenvironmental and subsistence-settlement models for the Middle Archaic period in Middle Tennessee are also presented.

The Site

The Anderson site, 40WM9, is a shell midden located on the east bank of the Harpeth River in Williamson County, 2 miles north of

Franklin, Tennessee, at 35°57'30" North Latitude and 86°53'30" West Longitude (Figure 1). Excavation was conducted in the 1980 and 1981 seasons by the Middle Cumberland Archaeological Society under the direction of John Dowd.

Cultural material scattered by plow disturbance indicated a total area of approximately 1 acre. Excavation was concentrated in the center of the midden, including about 15% of the total site (Dowd, personal communication). A 45 x 60 ft. area with a north-south base line was divided into 18 units of six 5-foot squares (Dowd 1981). In the absence of identifiable stratigraphy, the top 10 inches of the plowzone was designated as Level 1, with the remaining midden divided into 6-inch levels until sterile soil was reached. The maximum depth of the site was approximately 5 feet, with an average midden depth of 3½ to 4 feet (Dowd, personal communication). Soil samples from each level of the two center baulks were collected for later flotation and paleoethnobotanical analysis (Dowd 1981).

Forty-eight features were excavated at the Anderson site, of which hearths, firepits, activity areas, and pits of unknown function were the most abundant. One isolated dog burial was found in Level 2. Also present were two postmolds which suggest that structures were erected on the midden during its occupation (Dowd, personal communication).

Also recovered from the Anderson site were 73 relatively well-preserved burials. The following information about burial customs was taken from the burial records and photographs provided by

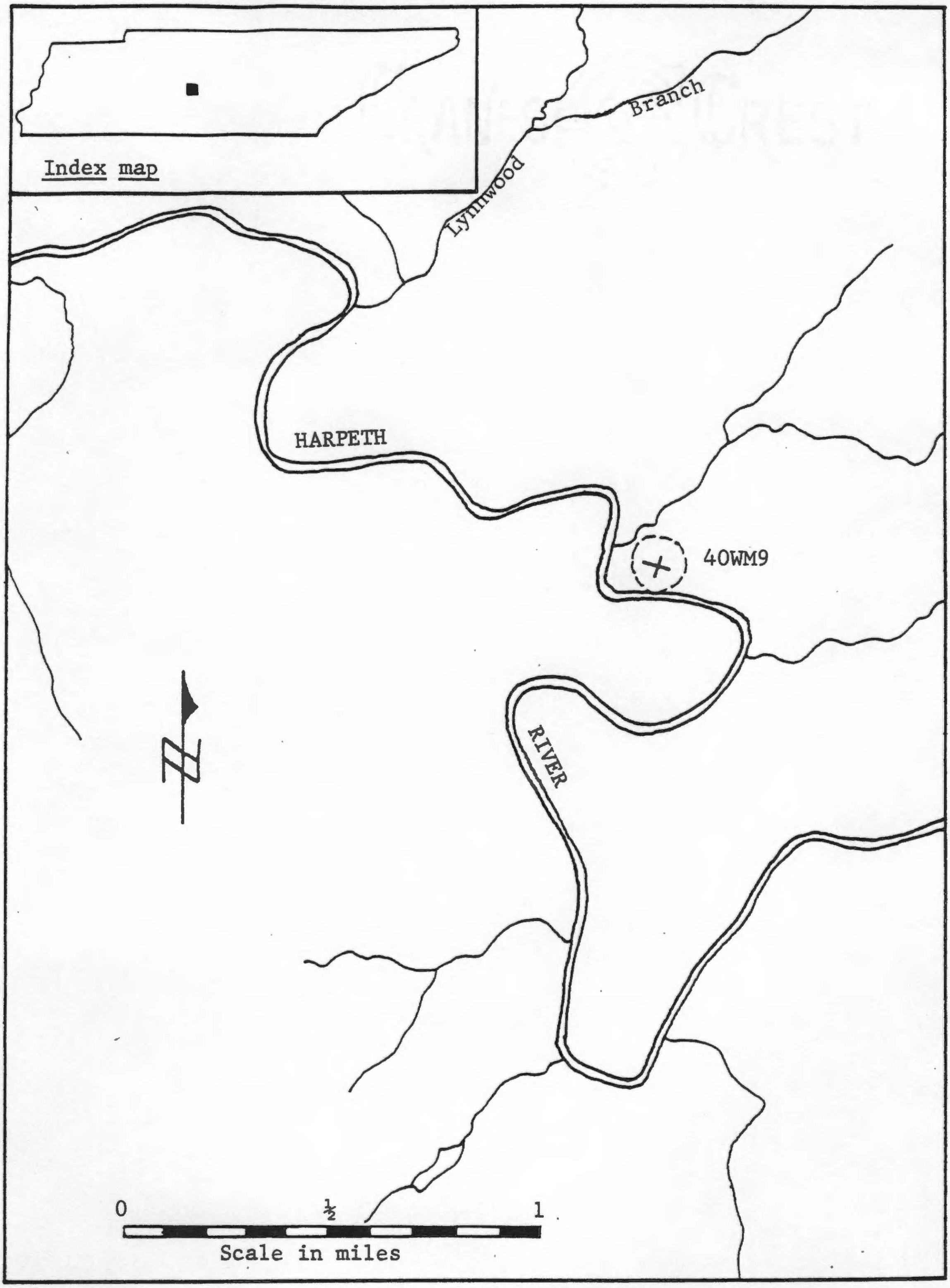


Figure 1. Location of the Anderson Site (40WM9) in Middle Tennessee (Source: United States Department of Interior Geological Survey 1949).

John Dowd. The usual burial position was either fully-flexed or semi-flexed. Of the three extended burials, two were infants and may represent cradle-board interments (Lewis and Lewis 1961:103). Three other burials were adult cremations. Although burial pits were usually indistinguishable from the general shell matrix, the infrequent occurrence of overlying and intrusive burials suggests that they were marked by the inhabitants (Dowd, personal communication). Burial goods were associated with 28, or about 38%, of the 73 burials, including both subadults and adults from each level of the midden. In general, no difference in burial customs is discernable between levels. Like the Archaic Eva site from the western Tennessee Valley (Lewis and Lewis 1961), the midden accumulation and presence of burials and features like postmolds and pits suggest that the Anderson site represents the base camp of either a single cultural group or a number of related groups.

Cultural Chronology and Relative Dating

Lewis and Kneberg (1959) defined two traditions for the Archaic period in the Midsouth. The validity of these traditions, however, has been challenged by recent archaeological and biological evidence. Bowen's (1975) reevaluation of the Late Archaic Cherry and Ledbetter sites in western Tennessee demonstrated that they were not manifestations of different traditions but were different parts in the seasonal round of the same overall settlement-subsistence system. Similarly, Cole's (1975) multivariate analysis of crania from the Eva, Indian Knoll, Kays Landing, and Perry sites failed to support the division of the Archaic into two distinct traditions. Close biological relationship could not be demonstrated for groups within a tradition nor for groups between traditions (Cole 1975:95).

Although Lewis and Kneberg's traditions are inappropriate, their cultural phases are still applicable in the chronological ordering of Archaic sites in the Midsouth (Lewis and Kneberg 1947, 1959; Lewis and Lewis 1961). On the basis of intensive shellfish exploitation and on the artifact assemblage, the Anderson site's closest cultural association is with the Eva and Three Mile Middle Archaic phases in the western Tennessee Valley (Lewis and Kneberg 1959; Lewis and Lewis 1961).

Two radiocarbon (C-14) dates were obtained for the lower levels of the Anderson site. A sample of charcoal fragments in ash (Sample GX-8215) dates Level 7 at 6720 $\pm$ 220 B.P., and a sample of wood charcoal (Sample GX-8365) dates Level 6 at 6495 $\pm$ 205 B.P. (Dowd, personal communication). Table 1 shows that these dates agree with those of other Middle Archaic components in Tennessee. Since a trustworthy C-14 sample was not available for the top layers, the time depth for the Anderson midden is estimated by relative dating of projectile point types.

Table 2 presents the stratigraphic distribution of projectile point types at the Anderson site (Bruce Lindstrom and Ken Steverson, personal communication). This distribution does not include Level 1 because it consisted of the plowzone and Level 8 is included in Level 7 because it was present in only two squares. Throughout the midden deposits diagnostic Middle Archaic projectile points characterized by the Eva-Morrow Mountain and Big Sandy types prevail. Radiocarbon dates for Eva-Morrow Mountain components in the Southeast

Table 1. Radiocarbon Dates For Eva-Morrow Mountain Components in the Southeast[1]

Site	Radiocarbon Date	Reference
Anderson, TN 40WM9	6720 ± 220 B.P. 6495 ± 205 B.P.	Dowd (personal communication)
Cave Spring, TN 40MU141	6885 ± 90 B.P. 6540 ± 110 B.P.	Hofman (1982:2)
Eva, TN 40BN12	7150 ± 500 B.P.	Crane (1956:666)
Eoff III, TN 40CF107	6525 ± 165 B.P.	Faulkner (1977:281)
Icehouse Bottom, TN 40MR23	6995 ± 245 B.P.	Chapman (1976:8; 1977:164)
Howard, TN 40MR66	7255 ± 165 B.P.	Chapman (1979:79-80)
Stucks Bluff Rock Shelter, AL 1LR34	6450 ± 120 B.P.	Dejarnette et al. (1975:113)

[1]Modified from Hofman (1982:2).

place this complex between 6450 B.P. and 7255 B.P. (Table 1). At some sites, White Springs projectile points are also associated with the Middle Archaic, representing what may be a Sykes variant (Cambron and Hulse 1975).

In a reevaluation of the Eva site projectile point types, Magennis (1977:23) found that the Eva-Morrow Mountain and Big Sandy types predominated in the lower two-thirds of the Middle Archaic level. In contrast, the top one-third of the Middle Archaic level consisted of corner removed points (e.g., the Provisional Corner

Table 2. Projectile Point Types at the Anderson Site[1]

Type	Level 2	3	4	5	6	7	Total
Morrow Mountain Rounded Base[2]	39	45	32	22	14	6	158
Morrow Mountain Straight Stem	53	55	68	49	23	3	251
Morrow Mountain Triangular[3]	9	9	6	80	70	26	200
Kirk	1	4	7	6	1	0	19
White Springs	9	5	1	2	0	0	17
Big Sandy	12	6	6	4	1	0	29
Lecroy	2	0	1	0	0	0	3
Decatur	1	1	0	1	0	0	3
Dalton	0	0	0	1	0	0	1
Beaver Lake	1	0	1	0	0	0	2
Clovis	0	0	1	0	0	0	1
Provisional Corner Notched I	28	25	9	2	0	0	64
Provisional Corner Notched II	0	2	2	2	2	2	10
Undifferentiated	59	54	50	46	40	16	265

[1]Provided by Bruce Lindstrom and Ken Steverson (personal communication).

[2]Includes "Eva" basally notched type.

[3]Described in Dejarnette et al. (1962).

Notched cluster at the Anderson site). This level was assigned to the Late Middle Archaic and given an estimated date of 4950 B.P. (Magennis 1977:24, 28).

In summary, the Anderson site was probably occupied at least from 6720 B.P. to 6450 B.P. and at the most from 6720 B.P. to 4950 B.P. The upper end of this range is based on the tenuous date assigned to the Provisional Corner Notched point type cluster in the upper midden deposits. Whether these represent new projectile points that were slowly being used over a period of several hundred years or whether they merely reflect functional differences in tool manufacture and utilization is not known. The latter situation, however, might suggest a shorter period of occupation at the Anderson site.

The Ecological Setting

The modern climate of Middle Tennessee is described as Humid Mesothermal (Strand et al. 1973). The mean annual precipitation for Franklin, Tennessee, is 40 inches. While annual dry spells are common in the summer and fall, heavy rainfall and flooding frequently occur in the winter and early spring (Dickson 1974). The average growing season for the Franklin area consists of 192 frost-free days from April through October. Recorded temperatures during the period 1931-1952 show mean maximum/minimum temperatures of 50°F and 30°F for January, respectively, and mean maximum/minimum temperatures of 90°F and 68°F for July, respectively (Dickson 1974).

Physiographically the Anderson site is located in the Nashville Basin (Fenneman 1938). Covering approximately 5900 square miles, this basin is divided at the base of the Hermitage geological formation into inner and outer segments (Edwards et al. 1974). The outer basin is characterized by the deep, rich soils of the major floodplains formed by the Elk, Duck, Harpeth and Cumberland Rivers (Edwards et al. 1974:2). The major soils along the Harpeth River are of the Lindside-Armour-Huntington association (True et al. 1961:7). In general, the Armour series are well-drained, fertile soils of stream terraces formed from phosphatic limestone and are typically found on 2 to 12 percent slopes (True et al. 1961:10-11). The well-drained, rich Huntington soils are located on the first bottoms with slopes usually less than 2 percent. Formed from limestone, these soils are medium to high in phosphorus, contain some acidity, and tend to be high in organic matter and available moisture capacity (True et al. 1961:30-31). Other soils of the first bottoms consist of the moderately well-drained Lindside series formed from limestone uplands. Like the Huntington soils, they tend to be acidic with dominant slopes between 0 and 2 percent (True et al. 1961:32-33).

Lying in the fertile Western Mesophytic Forest (Braun 1950), the vegetation of the Anderson site vicinity consists of deciduous hardwoods like beech, various oaks, hickory, gum, walnut, tulip tree, chestnut, black locust, elm, ironwood, hornbeam, dogwood, sourwood, wildcherry, maple, and hackberry (Edwards et al. 1974:2).

Traditional theories state that the Southeastern deciduous forests reached their modern composition and distribution in the Tertiary Period and were unaffected by the subsequent Pleistocene glacial climate (Braun 1950, 1955). Recent research of the paleoenvironment in the Southeast in general, and in Tennessee in particular, contradicts this conclusion (Delcourt 1979; Delcourt and Delcourt 1979). These authors have constructed a 25,000-year scheme for vegetation changes in the Southeast from the pollen and plant macrofossils of two Middle Tennessee sites, Anderson Pond in White County and Mingo Pond in Franklin County (Delcourt 1979; Delcourt and Delcourt 1979). According to this scheme, boreal-like coniferous forests with jack pine and spruce existed in Tennessee during the Full Glacial (25000-16500 B.P.). These were replaced during the Late Glacial (16500-12500 B.P.) by cool-temperate coniferous-deciduous forests between 34° and 37°N latitude. In the Early Holocene (12500-8000 B.P.), this same region was dominated by a cool-temperate mixed mesic forest. A warming and drying trend is indicated for the Mid Holocene (8000-5000 B.P.) when xeric forests with oak, hickory, and ash dominated Middle Tennessee. These were replaced in the Late Holocene (5000 B.P.) when an increase in annual precipitation produced the forest types of the historic Southeast.

The warming and drying trend of the Mid Holocene was due to the Hypsithermal Interval. First defined for the Northeastern United States, this continent-wide phenomenon dates from 8000-4000 B.P. in Minnesota with a peak at about 7000 B.P. (Wright 1976). In the Southeast, 'the alteration in forest composition and distribution during this interval was caused by the eastward expansion of the prairie grasses into the woodland areas' (Delcourt 1979:277). Since the Hypsithermal Interval is coeval with the Middle Archaic period in Tennessee, it is important in the analysis of populations living during this time (Hofman n.d.). The climatic and ecological changes during this interval would have affected the local availability of natural resources like water and animal and plant foods. Significant variations in these resources would have, in turn, affected the subsistence and settlement patterns of Middle Archaic groups (Hofman n.d.).

A reconstruction of the paleoenvironment during the Hypsithermal Interval is available for Cheek Bend Cave, 40MU261, in the Columbia Reservoir area (Klippel and Parmalee 1982). Located on the Duck River in the Nashville Basin, this well-stratified site is approximately 30 miles south of the Anderson site. Containing features of both the inner and outer Nashville Basin segments, this site is in a "mosaic of cedar glades and Western Mesophytic Forest" (Klippel and Parmalee 1982:8). At Cheek Bend Cave the stratigraphic distributional changes of the "insectivore sequence supports Delcourt's (1979) post-glacial vegetational changes in the Midsouth" (Klippel and Parmalee 1982:23). Boreal insectivores dominated the cave during the Full Glacial, were replaced by 'more heat tolerant species' in the Late Glacial, and finally disappeared by the Early Holocene (Klippel and Parmalee 1982:23-25). During the Mid Holocene a dramatic increase in insectivores favoring open habitats occurred, followed by a significant decrease in their frequency by the Late Holocene. Klippel and Parmalee stated that:

> . . . soricid remains clearly indicate a change in climate conditions within the Holocene *per se* . . . and . . . can be attributed to changing vegetation in the immediate vicinity of the cave (1982:25-26).

Charcoal from the site provides further evidence of changes in vegetation in the immediate vicinity of Cheek Bend Cave (Crites 1982). Hardwoods and cedars indicative of warm and/or dry conditions were well-represented in the Mid Holocene stratum but were replaced by more mesic taxa which infiltrated the area during the moister conditions of the Late Holocene (Crites 1982).

In summary, paleoenvironmental data for Middle Tennessee indicates that the Hypsithermal Interval of the Middle Archaic period had significant effects on the composition of both regional and local natural resources. Under such conditions, Middle Archaic groups may have been forced to alter their procurement strategies which, in turn, would have necessitated changes in their settlement patterns. It could be expected that an efficient biological adaptation to these cultural-environmental pressures would be reflected in skeletal material from this period in Middle Tennessee.

Subsistence and Settlement Systems

The paleoenvironmental information now available for the Midsouth indicates that Archaic groups were subjected to a variety of alterations in their local climate and vegetation. Two subsistence-settlement models interpret such environmental conditions as causal elements of cultural changes during the Archaic period in the Midsouth. The first model is based on the presumed occupation of sedentary hunter-gatherers at the Eva site in western Tennessee (Lewis and Lewis 1961). At this site the frequency of shellfish dramatically increased while animal bone decreased by a factor of five between the Eva and Three Mile components of the Middle Archaic level. A decrease in deer (the favored mammel in all components), was attributed to overexploitation by local Archaic groups and to increased aridity during the Hypsithermal Interval which turned the rich bottomlands into dry prairies. In turn, shallower waters provided a dependable, readily accessible supply of mussels (Lewis and Lewis 1961:20). In contrast, the subsequent Big Sandy component was totally devoid of mussels, a phenomenon probably caused by the moister climate and frequent floods of the Medithermal Interval during the Late Archaic period. In fact, these floods probably contributed to continued periods of local food shortages which influenced the abandonment of the Eva site (Lewis and Lewis 1961).

Lewis and Lewis' (1961) evidence for an Archaic culture change is included in Hofman's (n.d.) reinterpretation of the Mid Holocene adaptation in the Central Duck River Basin, located about 30 miles south of the Anderson site. Based on their close geographical proximity, it is likely that the human ecology of these two areas is similar. Hofman (n.d.) proposed that environmental changes caused by the Hypsithermal Interval forced band-level societies to exploit a wide range of plant and animal food resources including primary species like deer and nuts from the upland areas and secondary species like smaller mammals, shellfish, fruits, seeds, and roots from the immediate vicinity of the base camp. According to Hofman (n.d.:12-14), an abundance of deer and gastropod remains as well as the presence of plant processing tools at sites like Anderson support the idea of a "broad-spectrum economy" for Middle Archaic populations in Middle Tennessee. It is likely that the proposed dietary resources provided the small groups of hunter-gatherers with favorable dietary conditions. For example, Hofman (n.d.:17-22) pointed out that deer and hickory nuts are known to be high in protein, fat and calories and acorn nuts in carbohydrates (Asch et al. 1972; Parmalee and Klippel 1974). Among the secondary species, shellfish provide required minerals like calcium, iron, sodium, and potassium (Parmalee and Klippel 1974), and other fish, mammals, fruit, and vegetable foods provide supplementary nutrients. A preliminary identification of fauna remains from the Anderson site indicates an abundance of deer as well as variable presence of other mammals like raccoon, beaver and squirrel, and of turkey, duck, turtle and fish (Emanuel Breitburg, personal communication). Charred nut remains were also found during the excavation of the midden (Dowd, personal communication). Among modern hunter-gatherers, traditional diets based on a wide range of mammal, fish, nut and vegetable foods generally buffers the population from malnutrition and starvation (cf., Kolata 1974; Truswell and Hansen 1976; Turnbull 1965).

In summary, the Anderson site probably represents a base camp occupied over several generations by a homogeneous population of Middle Archaic hunter-gatherers. Although most of the subsistence activities were probably conducted in the immediate vicinity of this site, periodic movement to other resource areas likely occurred on a scheduled seasonal basis. For example, the procurement of deer and nuts would have necessitated movement to the upland areas. It is also likely that settlements were organized into small egalitarian bands (Service 1975:60-61), wherein reciprocity and constant movement between groups of the same territory were common occurrences.

Evidence suggests that changes in the environment of Middle Tennessee forced Middle Archaic populations to adopt a semi-sedentary lifestyle based on intense exploitation of a broad range of local plant and animal food resources. The biological adaptive success of the Anderson population to these cultural-environmental conditions is inferred through an investigation of its demographic, long bone growth, and pathology patterns.

CHAPTER III

DEMOGRAPHY

I. INTRODUCTION

The study of human adaptation focuses on the interaction of populations with their specific environments. In this context, a "stress" is any environmental perturbation that elicits a human response, be it biological, behavioral, or cultural (Moran 1979:6). New stresses are potentially devastating to small hunter-gatherer societies which live in an intimate relationship to each other and their environment. Protection from the latter is secured by the maintenance of a simple technology and a flexible socio-economic structure. Spatial mobility between groups and between members of groups enhances adaptation by creating social and economic alliances between local bands and by maintaining a low population density which, in turn, secures the local food supply. Under these socio-economic conditions, a precarious balance is achieved between small hunter-gatherer groups and their environment.

It is the socio-economic factors that affect any population's demographic parameters of longevity and mortality (Acsadi and Nemeskeri 1970:25). A group's settlement-subsistence patterns expose individuals to a variety of environmental circumstances upon which successful biological resistance and adaptation are age-dependent. According to Acsadi and Nemeskeri (1970:25) the 'breakdown of these capabilities will cause death in old age but that death in younger years is more commonly caused by diseases.'

As Berryman (1981) and Owsley (1975) pointed out, most work in the adaptation of demographic theory and methodology to archaeologically-derived skeletal remains has occurred since the mid-1960's. The following statement provides a reiteration of these authors' general opinions concerning skeletal material and the place it has in paleodemographic research.

> It is evident that the more use is made of factors having a biological component, the closer one comes to the reality of population, a biological phenomenon. Finally, we come to skeletal material, the most important evidence of all, since it is completely biological, and one individual however many rooms he may occupy or however many clams he may eat or pots he may make, produces one skeleton and one only (Howells 1960:160).

Skeletal samples also present unique problems which may limit their usefulness in paleodemographic research. Briefly summarized from Berryman (1981) and Owsley (1975), the primary problems facing physical anthropologists are that the skeletal sample has been drawn for them and may contain biases due to poor preservation of infants and osteoporotic adults, cultural burial practices, and archaeological recovery techniques. While these problems should not be ignored, they should neither be grounds for not analyzing skeletal material because as Howell (1976:25) noted, "we cannot realistically expect to ever find archaeological evidence that will permit us to solve the problems of paleodemography in a completely empirical manner, even for one group." Besides, skeletal remains are our only means of understanding the biological prehistory of human populations (Brothwell 1968).

II. THE PALEODEMOGRAPHIC APPROACH

Several authors have discussed the development of paleodemographic research in physical anthropology (Berryman 1981; Owsley 1975; Palkovich 1978; Ubelaker 1974). The following highlights some of these developments. Paleodemography is based on the accurate determination of the age-at-death distribution of a skeletal sample. Although the first skeletal ageing standards were developed in the early part of the 20th century (Todd 1920, 1921; Todd and Lyon 1924, 1925), few subsequent demographic studies have been conducted on Amerindian skeletal remains because of sample size problems and because of the cultural factors of the population itself (Howells 1960; Ubelaker 1974; Vallois 1960). A case in point is Hooton's (1930) well-known analysis of the Pecos Pueblo skeletal series (Ubelaker 1974:6). Using this series as well as ethnohistoric sources and archaeological data, Hooton attempted to estimate changes in population size during the pueblo's occupancy. According to Ubelaker (1974:6) these estimates are unreliable because of a discrepancy noted by Howells (1960) in reports of the representative nature of this skeletal series.

Since 1940 three paleodemographic approaches have been applied in the analysis of Amerindian skeletal remains. In one approach, a mortality curve is constructed to reflect the percent of people dying in each age interval (Blakely 1971; Johnston and Snow 1961; Snow 1948). Unfortunately, the early studies by Johnston and Snow cannot be used in population comparisons because older adult ages were determined by cranial suture closures and by dental attrition; both features are now considered to unreliable age indicators (Stewart 1962). Blakely's (1971) study, however, demonstrated that with better ageing techniques, mortality profiles provide one means of standardizing comparisons between populations.

As more thoroughly discussed in Berryman (1981) and Owsley (1975), the second paleodemographic approach involves a unique combination of estimating both the ages at death for a population as well as the number of children born to each female (Angel 1969). From these figures the population's longevity, death and sex ratios, fecundity, fertility, and growth rates are derived. The main problem with this approach is that Angel estimates fecundity from the degree of parturitional scarring present on the female pubic symphysis. As Berryman (1981:45-46) stated, these features have neither been found to correlate with known cases of parity (Gilbert 1973) nor to aid in the prediction of full-term pregnancies (Suchey et al. 1979). The problems associated with the interpretation of parity, therefore, limit the application of this approach to other skeletal samples (Berryman 1981: 46).

The most accurate and widely used approach in paleodemography is the application of the life table methodology to skeletal remains (Bennett 1973a; Berryman 1981; Lovejoy et al. 1977; Magennis 1977; Owsley 1975; Owsley and Bass 1979; Palkovich 1978; Ubelaker 1974). As developed by Lotka (1907) life tables standardize the age-specific death rates of a population, thereby facilitating direct inter- and intra-population comparisons of age and sex patterns. The applicability of the life table to skeletal populations is based on two critical assumptions. Briefly summarized from Acsadi and Nemeskeri (1970), the skeletal series is first assumed to represent a biological cohort regardless of its time depth. This assumption is justifiable if the series is further assumed to approximate a stable and stationary population. Such a population is characterized by equal birth and death rates, a zero-growth rate, fixed age-specific death rates, and no net migration (Acsadi and Nemeskeri 1970:61). These authors postulated that the population explosion is a recent phenomenon and that 'it can be assumed that the stationary population theory closely approximates the circumstances of prehistoric populations' (Acsadi and Nemeskeri 1970:45).

III. PREREQUISITES FOR PALEODEMOGRAPHIC ANALYSIS

Demographic methodology is based on random samples drawn from living populations and is applicable to skeletal samples that are representative of the populations from which they are derived. Skeletal samples are considered to be adequate for demographic analysis if they meet five basic prerequisites. These are:

> 1) a knowledge of the completeness of the sample; 2) information about the archaeological associations of the skeletons; 3) a determination of the length of time the sample represents; 4) an adequate assessment of sex and age at death; and 5) a proper selection of demographic methodology (Ubelaker 1974:5).

Reconstructed demographic parameters are useful in determining the structure of a population (Magennis 1977) and can be used to infer the adaptive success of a given prehistoric population to its environment (Ubelaker 1974). The following is an examination of these prerequisites in reference to the Anderson skeletal sample.

Completeness of the Anderson Sample

Unfortunately, a lack of funds prevented the total recovery of the Anderson site (Dowd, personal communication). Every effort was made, however, to obtain the most complete and accurate sample possible from the site. Excavation focused on the deepest area of the center of the midden. Burial recovery included the removal of all skeletal parts. Although different areas of the site, i.e., the periphery, were not excavated, it appears that many biases often associated with the procedures of burial recovery are not a major problem with the Anderson skeletal sample.

Other sources of bias in a skeletal sample include partial destruction of the series and differential exclusion of certain individuals due to sex or age. A skeletal sample can be partially destroyed by ground disturbance and by differential skeletal preservation. A relatively large pit, previously dug on the site, prompted excavation of the Anderson midden, which included the area adjacent to, but not including, the disturbed area (Dowd, personal communication). Despite plow disturbance in the top 10 inches of the Anderson midden, this layer still produced 10 distinct burials. Surface scatter indicated plow destruction of other skeletons, the actual number of which cannot be accurately calculated but is assumed to be minimal (Dowd, personal communication). In addition, differential preservation and burial practices may lead to the underrepresentation of infants and children in skeletal samples. Preservation of both infants and children at the Anderson site was exceptional. Careful recovery of these burials produced such delicate features as unerupted deciduous tooth buds and numerous unfused epiphyses of long and short bones. Problems of differential preservation, therefore, do not appear to be a serious problem at the Anderson site. Finally, an examination of Appendix A indicates that cultural biases introduced by intentional differential interment is probably not a serious problem at the Anderson site. Not only are all age levels and both sexes represented, but burial goods are associated with young and old and with males and females alike.

In summary, the above information suggests that the Anderson skeletal sample is a reasonable approximation of the individuals who died during its occupation; it does not suggest that the series represents a total population.

Archaeological Association of the Skeletons

Although burial pits were usually indistinguishable from the general midden matrix, the integrity of each skeleton was maintained by the horizontal and vertical controls employed by the excavators (Dowd 1981). Using these procedures, 71 definable burials were carefully excavated, mapped, and photographed *in situ*. These burials were then placed in separate boxes labeled with the burial and unit numbers, date of excavation, and level of deposition. Burial records and photographs accompanied these bones to the Physical Laboratory at the University of Tennessee, Knoxville, where the burials were cleaned and catalogued. In the laboratory, field identification information accompanied the bones throughout the processing procedures.

Emanuel Breitburg and John Dowd (personal communication) identified two other relatively complete burials in their laboratory during their respective preliminary analyses of the faunal remains and of the contents of the archaeological features excavated at the Anderson site. These include Burial 72, an infant, which was found in a bag containing the remains of a fetal deer, and Burial 73, an adult cremation, which was found in debris from Feature 1, a firepit which also contained numerous fragments of deer bone and antler.

For the purpose of the present study, it is assumed that the excavation and laboratory procedures employed in the recovery and analysis of the Anderson skeletal series have provided a reasonable sample for demographic analysis.

Length of Occupation

The exact time depth of the Anderson site is not known (see Chapter II). Carbon 14 dates for the bottom layers and relative dates for projectile point types associated with the top layers suggest a total midden accumulation of at least 270 years. The absence of variation in burial practices and the absence of intrusive or overlying burials further suggest that the site was a base camp occupied seasonally by one or more closely related groups of Middle Archaic hunter-gatherers.

Age and Sex Determination

Paleodemography is based on the accurate determination of both the age-at-death and the sex of a skeletal series. Comprehensive reviews of the known skeletal age and sex indicators are provided by Krogman (1962), Bass (1971), and Stewart (1979). The selection, and the reliability, of criteria used in the estimation of age and sex for a given sample, however, are generally affected by the completeness of the burials as well as the general morphological features of the skeletal series. For this reason, the age and sex estimates for the Anderson skeletal series were derived following the method suggested by Lovejoy:

> In summary this method involves the aging and sexing of a "core" population of well-preserved skeletons, identification of significant secondary age and dimorphic indicators in this population segment, and application of these vectors to the "peripheral" segments for the most accurate demographic identification (1971:102).

The distribution of age and sex of the Anderson skeletal series is provided in Appendix A.

Age determination. Different techniques are available for subadult and adult age determination. The criteria employed for subadult age estimation in the Anderson skeletal sample were the rate of dental calcification, long bone lengths, and the rate of epiphyseal union.

The rate of dental calcification and long bone lengths were used to estimate the ages of prepubescent skeletal remains (less than 12 years of age). The rate of dental calcification is considered to be the most reliable indicator of developmental age in subadults (Merchant and Ubelaker 1977; Ubelaker 1978). In the absence of chronologies of dental calcification in living Indian children, the usual calcification standards applied to Amerindian skeletal remains are those derived from a modern sample of American White children (Moorrees et al. 1963a, 1963b). These standards, however, may provide inaccurate ages if the timing of mineralization in Indian children differs from the timing in White children (Merchant and Ubelaker 1977:71; Moorrees et al. 1963b:1500; Ubelaker 1978:46). Owsley and Jantz (n.d.) investigated the analytical importance of such a timing difference by performing pairwise contrasts of dental ages obtained from the calcification rates of the permanent dentition of a sample of Arikara children and of the sample of White children in Moorrees et al. (1963b). These contrasts revealed that Indian children were advanced in dental development by 0.5 to 1.1 years in the maxillary incisors and mandibular second molars and by more than 2 years in the third molars. Under these circumstances, Owsley and Jantz (n.d.) suggested that more consistent age estimates could be achieved for demographic and growth studies by rating selected blocks of teeth like the premolars. In a subsequent study of Arikara long bone growth, Jantz and Owsley (n.d.) outlined a new dental ageing procedure for prepubescent Amerindian skeletal remains. In this procedure, mean ages associated with each developmental stage in Moorrees et al. (1963a, 1963b) were assigned to two subsets of five mandibular teeth, the deciduous canine (c) and second molar (m_2), and the permanent first molar (M_1) and first (P_1)

and second (P_2) premolars. Age adjustments amounting to the difference in the age of development between two teeth were then made to the slower developing teeth so that all teeth within a subset had the same average age (Jantz and Owsley n.d.:7). A more detailed discussion of the theory and methodology behind this dental ageing procedure can be found in Jantz and Owsley (n.d.) and Owsley and Jantz (n.d.).

Theoretically, the adjusted dental ages provided in Jantz and Owsley (n.d.) are only applicable to the Arikara groups from which they were derived or to other related Plains Indian groups. However, if potential differences in Indian dental calcification rates are realized, then these adjusted ages are probably more reliable as age estimators for other Indian skeletal populations than those dental ages provided by the sample of White children in Moorrees et al. (1963a, 1963b). This is especially true in skeletal populations that lack a sufficient sample from which to derive a reliable dental development schedule.

Following Jantz and Owsley (n.d.) the same subsets of mandibular teeth were rated using the tooth formation stages developed by Moorrees et al. (1963a, 1963b). The coding format for this procedure is provided in Appendix B. Loose teeth were rated by visual inspection and unerupted teeth from periapical x-rays. From these rates, computer assigned ages were given up to 2 years using the mean of c and m_2, or the presence of either tooth alone, where c and m_2 were adjusted to M_1 ages by adding 0.26 and 0.47

years to their ages respectively. The mean of M_1, P_1, and P_2, or the combination of those present, were used to assign ages from 2 to 11.9 years where P_1 and P_2 were adjusted to M_1 by subtracting 0.27 and 0.51 years from their ages respectively.

In prepubescent remains without teeth, age estimates were obtained by comparing the lengths of their long bones to the appropriate regression lines. The general linear model procedure, GLM (SAS Institute 1982) was used to calculate the regression equations. Here, model: bone length = $b_o + b_1(\text{age}) + b_2(\log_{10}\text{age})$ was used. Only the remains with both teeth and long bones were included in this analysis. Maximum diaphyseal length was recorded in millimeters for the radius, humerus, femur and tibia. Whenever possible measurements were taken on left bones using either a sliding caliper or an osteometric board, depending on the size of the bone (Bass 1971). Right bones were substituted in cases where the left was either absent or fragmented. The coding format for the growth data is presented in Appendix B and the regression lines in Chapter IV.

Ages for postpubescent and young adult remains (ages 12 through approximately 25 years) were estimated using the epiphyseal closure standards developed by McKern and Stewart (1957) and Krogman (1962) and the chart developed by McKay (1961).

Several methods were used to estimate adult ages (approximately 18+ years). In order of reliability these methods include the degree of morphological change on the pubic symphysis, the degree of vertebral osteophytosis, and the degree of arthritic modification of the non-vertebral articular joints. Whenever possible, the metamorphosis of the pubic symphysis was used to estimate adult ages. Females were aged using the Gilbert and McKern (1973) method; males less than 40 years of age were aged using the McKern and Stewart (1957) method and those over 40 years were aged with the Todd (1920, 1921) method. In the absence of the pubic symphysis the degree of degenerative vertebral osteophytosis was used as a "general" indicator of adult age (Stewart 1958; Ubelaker 1978). Finally, the degree of degenerative changes in non-vertebral articular joints were assessed in the four burials (B30, B37, B62, and B69) which lacked both pubic symphyses and vertebrae. To control for errors inherent in the latter two ageing techniques, comparison was made with these features in the burials aged by the pubic symphysis. This procedure assumes that degenerative changes in the vertebral and non-vertebral joints progressed at the same rate in all Anderson adults. As a further precaution, degenerative ageing criteria were not utilized in cases which exhibited signs of localized trauma.

Various adult ageing criteria were unsuitable for the Anderson skeletal sample. For example, several skulls were at least partially reconstructed but the former signs of cranial suture closures were impossible to assess. The degree of dental attrition was also inapplicable due to the extensive amount of dental wear displayed in the adult dentition. Finally, osteon counting, one of the most accurate means of assessing adult age (Kerley 1965; Ubelaker 1978) was considered inappropriate for the present study due to its expense and its destructive nature.

Sex determination. Prepubescent skeletal remains are rarely complete enough to be accurately sexed by the methods currently available (e.g., Hunt and Gleiser 1955). In addition, the indicators of sex which are manifest on the adult skeleton are usually indistinct to absent in subadults (i.e., remains less than 18 years of age). Therefore, no attempt was made to sex subadult skeletons and no assumption was made concerning the sex distribution in this age category.

Several relatively accurate methods are available to determine sex in adult skeletal material. The estimation of sex in the Anderson remains was based on: 1) morphological features of the pelvis and skull; 2) anthropometric measurements of the femoral head, femoral shaft, and humeral head; and 3) the degree of skeletal ruggosity and robusticity. Depending on the completeness of the skeleton, the assignment of sex was made on either all of the above criteria or a combination of those present.

Pelvic features used to assess the sex of Anderson adults included: 1) the size of the acetabulum, the elevation of the sacro-iliac joint, the shape of the sciatic notch, and the definition of a pre-auricular sulcus (Bass 1971; Krogman 1962); 2) the presence of parturition scars in females (Houghton 1974; Putschar 1976; Stewart 1970); and 3) the shape of the ventral arc, subpubic concavity, and the medial aspect of the ischio-pubic ramus of the os pubis (Phenice 1969).

Although most of the skulls in the Anderson series could not be reconstructed, several of the sexually dimorphic features of the adult crania could still be assessed. Of importance were the sizes of the mastoid process, the palate, the supraorbital ridge, and the mental eminance; and the shapes of the superior border of the orbit and of the mandibular mental region (Bass 1971; Keen 1950).

Anthropometric measurements were taken following the methods defined by Bass (1971) for the maximum diameter of the femoral head, the maximum femoral shaft circumference, and the maximum diameter of the humeral head. The left bone was measured if present; if not, the right was substituted. Only those measurements falling clearly in the "male" or "female" ranges defined by Pearson and Bell (1919) for the maximum diameter of the femoral head, by Black (1978) for the maximum femoral shaft circumference, and by Dwight (1905) for the maximum diameter of the humeral head were used in the estimation of sex. Among Anderson adults, the best discriminations were obtained from the humeral head and the femoral shaft.

In a final analysis, the degree of ruggedness was noted for each specimen. In general, the bones of the Anderson males were larger and heavier with more clearly defined muscle markings than those of the females.

Demographic Methodology

As previously discussed, the application of life table methodology is the most accurate and widely used approach in the analysis of Amerindian demographic parameters. Two types of life table methodologies are available, the United Nations Model Life Tables and the composite life table. The United Nations Model Life Tables (United Nations 1955) were constructed to estimate the demographic parameters of under-developed countries with incomplete mortality records. Based on the vital statistics of 158 nations for the period A.D. 1900-1950, these tables serve as an approximation of the modern range of mortality. Several limitations, however, are associated with the application of these life tables to archaeologically-derived skeletal samples. The primary limitation is that the skeletal population's intrinsic rate of growth, r, must be known or approximated before a comparison to these tables can be made. Unfortunately, an accurate method of estimating r from skeletal samples has not been developed (Bennett 1973a; Carrier 1958; Palkovich 1978). Another serious limitation is that the demographic parameters of the skeletal population must be assumed to correspond to those of a model life table. As Palkovich (1978) pointed out, the range of biological forces which affect the mortality experience of modern nations cannot be assumed to represent those which operated on prehistoric populations. For these reasons, the United Nations reference tables are not applicable to archaeological skeletal remains (Acsadi and Nemeskeri 1970; Bennett 1973a; Carrier 1958; Palkovich 1978).

The most appropriate demographic approach is the composite life table because it is based on the age-at-death distribution of a skeletal sample. This approach, however, has been criticized as a "falsification of the biological facts" because:

> . . . it rests on three false assumptions: that the cemetery represents a single generation cohort, that death rates are even at all ages after infancy and hence directly reflected in cemetery age frequencies, and that the population is virtually stable biologically and socially over the period of cemetery use (Angel 1969:428).

The importance of these problems formed the bases of other studies concerning the applicability of life table methodology to prehistoric skeletal populations. For example, the problem of demographic stability in small human populations was addressed by Weiss and Smouse (1976) who suggested that in some skeletal samples:

> . . . the stochastic processes of life and death do not provide any substantial problem to the analysis of skeletal demographic data, if deposition has accumulated over a few generations. The overwhelmingly more important problems with data involve the proper exhumation of juveniles, correct ageing of skeletons, and the representativeness of the cemetery. Often, with care, these can be overcome . . . (Weiss and Smouse 1976:70-71).

Although the Anderson site represents the accumulation of an unknown number of generations of occupancy, it does not qualify as a large cemetery. For small skeletal samples, especially those with non-triangular age pyramids, Weiss (1973:15) suggested that smoothing (i.e., "averaging three adjacent age classes to produce a size for the central class"), would minimize stochastic irregularities present in the sample's age distribution. Briefly summarized, the procedure developed by Weiss (1973:42-43) involves applying these smoothed age distributions to the reference life tables which he developed. The skeletal sample is assumed to represent a normal stationary population if a "good fit" is obtained between the smoothed data and an appropriate reference table. Although these reference tables are the only ones available for anthropological skeletal samples, they, like the United Nations model life tables, must be approached with caution. Weiss (1973:43) himself noted that these tables might be biased since the younger ages were mainly based on data from skeletal populations and the older ages were based on data from contemporary 'healthy' populations. In addition, the populations used in these models represent broad technological levels, from hunter-gatherers to agriculturalists, but Weiss failed to specify which population was included in the calculation of a given reference table. Further, these tables may not represent the total range of prehistoric mortality experience. Indeed, the circumstances surrounding every population are unique and many may have normal life tables but not match one of Weiss' (1973). For these reasons, the reference tables developed by Weiss (1973) were not used in the present study.

In summary, the Anderson skeletal sample, like most archaeological samples, does not meet all the "ideal" requirements for paleodemographic research (Howell 1976:25; Ubelaker 1974:92). Only the recovery of other sizeable Middle-Late Archaic skeletal samples within the Midsouth, and more specifically within Middle Tennessee, will demonstrate the representativeness of the Anderson sample. This sample, however, provides the first opportunity for a biological interpretation of Middle-Late Archaic population dynamics in Middle Tennessee. A life table was reconstructed for the Anderson skeletal sample with an understanding of the limitations of the stationary population theory; the sample does not represent a total population but is assumed to be a reasonable approximation of the individuals who died during its occupation.

IV. LIFE TABLE CALCULATIONS

The demographic parameters for the Anderson skeletal series are reconstructed in an eight-column abridged life table. The following is a summary of the calculations for these columns as defined by Acsadi and Nemeskeri (1970).

Column one, x, presents the age intervals. The length of the first interval is one year (0-1), the second is 4 years (1-4), and the rest are in increments of 5 years with the exception of the last two intervals where the reliability of ageing skeletal remains is most difficult. For this reason, a 10-year interval is used for the years 40-49 and the remaining category represents all ages over 50 years. All recovered burials were included in computing the life table. Adult skeletons lacking the criteria for age determination, (Burials 31, 53, 73; all cremations), were evenly distributed throughout the adult age range (20+ years). The five burials (30, 37, 41, 62, and 69) with finer age estimates made by assessing the degree of degenerative changes present on non-vertebral joint surfaces were evenly distributed among adjacent age intervals. In this procedure the percent of adults with estimated ages was first obtained for each age interval. The number of adults with unknown or approximate ages was then multiplied by the percentage figures for each age interval within the estimated age range of these burials (i.e., 20+, 30+, 35+, or 30-39 years). The products were then added to each age interval, respectively.

The second column, Dx, represents the number of dead individuals in each interval, or between x and x+1.

The third column, dx, is the proportion of deaths in each age interval and is calculated by:

$$dx = \frac{Dx}{\sum_{x=0}^{w} Dx}$$

where: w = the maximum age attainable (i.e., 50+ years); and
x = the initial age category (i.e., 0-1 years).

The survivorship for each age interval, lx, is calculated in the fourth column by the function:

$$\ell_{x+1} = \ell x - dx$$

The initial value, lx, is set at 100.00 and subsequent values are derived by subtracting the percent dead, dx, from the given percent of individuals alive at the beginning of the age category, for example:

$$\ell_{0-1} = 100.00 \qquad \text{and} \qquad \ell_{1-4} = \ell_{0-1} - d_{0-1}$$

Column five, qx, represents the probability of dying in one age interval before reaching the next interval and is calculated by dividing the number of deaths by the number of survivors in each age interval:

$$qx = \frac{dx}{lx}$$

The number of years lived by the survivors of each age interval is represented by the sixth column, Lx. Three formulas are utilized to calculate this statistic. For the first age interval:

$$L_{0-1} = 0.2(\ell_{0-1}) + 0.8(\ell_{1-4})$$

For the second age interval:

$$L_{1-4} = 0.34(\ell_{0-1}) + 1.184(\ell_{1-4}) + 2.782(\ell_{5-9})$$

For the remaining age intervals:

$$Lx = \frac{n(\ell_x + \ell_{x+1})}{2}$$

where: n = the number of years in the age interval.

Values in the seventh column, Tx, represent the total number of years lived by the survivors of each age interval. The first value, T_{0-1}, is set to the sum of the Lx column:

$$T_{0-1} = \sum_{x=0-1}^{w} Lx$$

and subsequent values are obtained by subtracting Lx from Tx; for example:

$$T_{1-4} = T_{0-1} - L_{0-1}$$

$$T_{5-9} = T_{1-4} - L_{1-4}$$

The final column, e_x^o, expresses the expectation of life at each age interval and is computed by:

$$e_x^o = \frac{Tx}{1x}$$

Three life tables are usually computed for a skeletal population, one for each sex separately and one for both sexes combined. The sexes at all ages were combined for the Anderson demographic profiles because the sample size and the inability to estimate subadult sex reduce the reliability of inferences made on sex-specific calculations.

V. THE LIFE TABLES OF THE ANDERSON SKELETAL SERIES

Abridged life tables based on both unsmoothed and partially smoothed age-at-death distributions for the Anderson skeletal sample are presented in Tables 3 and 4, respectively. A nontriangular age pyramid is produced by the raw age-at-death, Dx, data in Table 3. This situation is probably caused by errors inherent in the skeletal sample (e.g., ageing biases, especially in the adult years where a number of burials could only be given "approximate" ages via assessing the degree of degenerative changes on the articular joints). For this reason, the more internally consistent smoothed data were used in this study. (Note that the smoothing procedure slightly inflates the total Dx value to 73.82 individuals.) The vital statistics on mortality, survivorship, age-specific probability of death, and life expectancy are investigated to infer the adaptive success of the Anderson population to its specific cultural-physical environment. Graphic illustrations of these demographic parameters are presented in Figures 2 through 5. Unsmoothed curves are presented for consistency.

Table 3. Abridged Life Table for the Anderson Site for Combined Sex: Unsmoothed Values

x	Dx	dx	lx	qx	Lx	Tx	e^o_x
0-1	14.00	19.18	100.00	0.192	84.66	2530.87	25.31
1-4	4.00	5.48	80.82	0.068	339.29	2446.21	30.27
5-9	3.00	4.10	75.34	0.054	366.45	2106.92	27.97
10-14	7.00	9.59	71.24	0.135	332.23	1740.47	24.43
15-19	6.00	8.22	61.65	0.133	287.70	1408.24	22.84
20-24	4.39	6.01	53.43	0.112	252.13	1120.54	20.97
25-29	1.10	1.51	47.42	0.032	233.33	868.41	18.31
30-34	6.69	9.16	45.91	0.200	206.65	635.08	13.83
35-39	4.15	5.69	36.75	0.155	169.53	428.43	11.66
40-49	15.11	20.70	31.06	0.666	207.10	258.90	8.34
50+	7.56	10.36	10.36	1.000	51.80	51.80	5.00

Table 4. Abridged Life Table for the Anderson Site for Combined Sex: Smoothed Values

x	Dx	dx	lx	qx	Lx	Tx	e^o_x
0-1	14.00	18.97	100.00	0.190	84.84	2321.85	23.22
1-4	7.00	9.48	81.03	0.117	328.99	2237.01	27.61
5-9	4.67	6.33	71.55	0.088	341.93	1908.02	26.67
10-14	5.33	7.22	65.22	0.111	308.05	1566.09	24.01
15-19	5.80	7.86	58.00	0.136	270.35	1258.04	21.69
20-24	3.83	5.19	50.14	0.104	237.73	987.69	19.70
25-29	4.06	5.50	44.95	0.122	211.00	749.96	16.68
30-34	3.98	5.39	39.45	0.137	183.78	538.96	13.66
35-39	8.65	11.71	34.06	0.344	141.03	355.18	10.43
40-49	8.94	12.11	22.35	0.542	162.95	214.15	9.58
50+	7.56	10.24	10.24	1.000	51.20	51.20	5.00

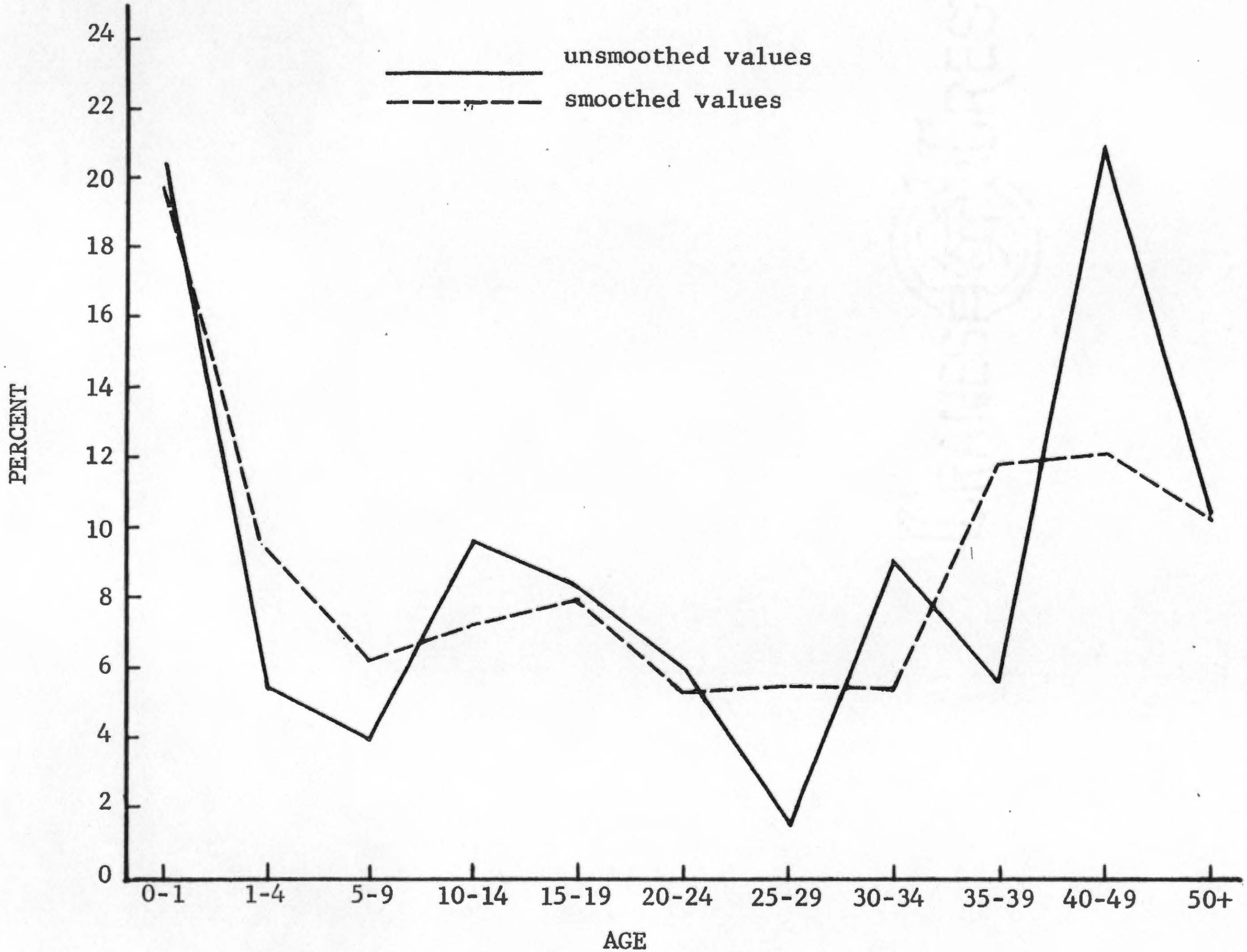


Figure 2. Mortality Curves (dx) For Combined Sex.

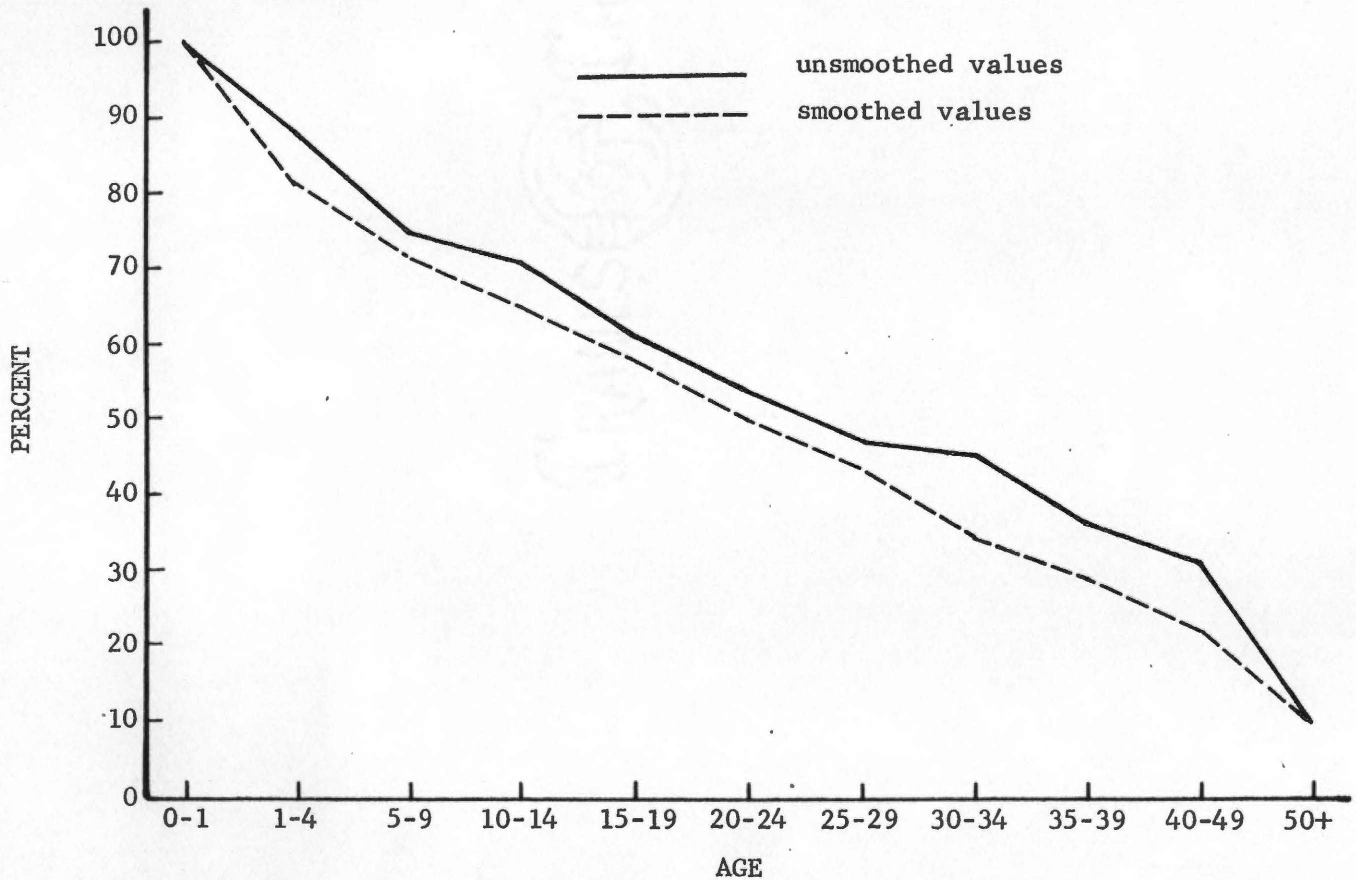


Figure 3. Survivorship Curves (lx) For Combined Sex.

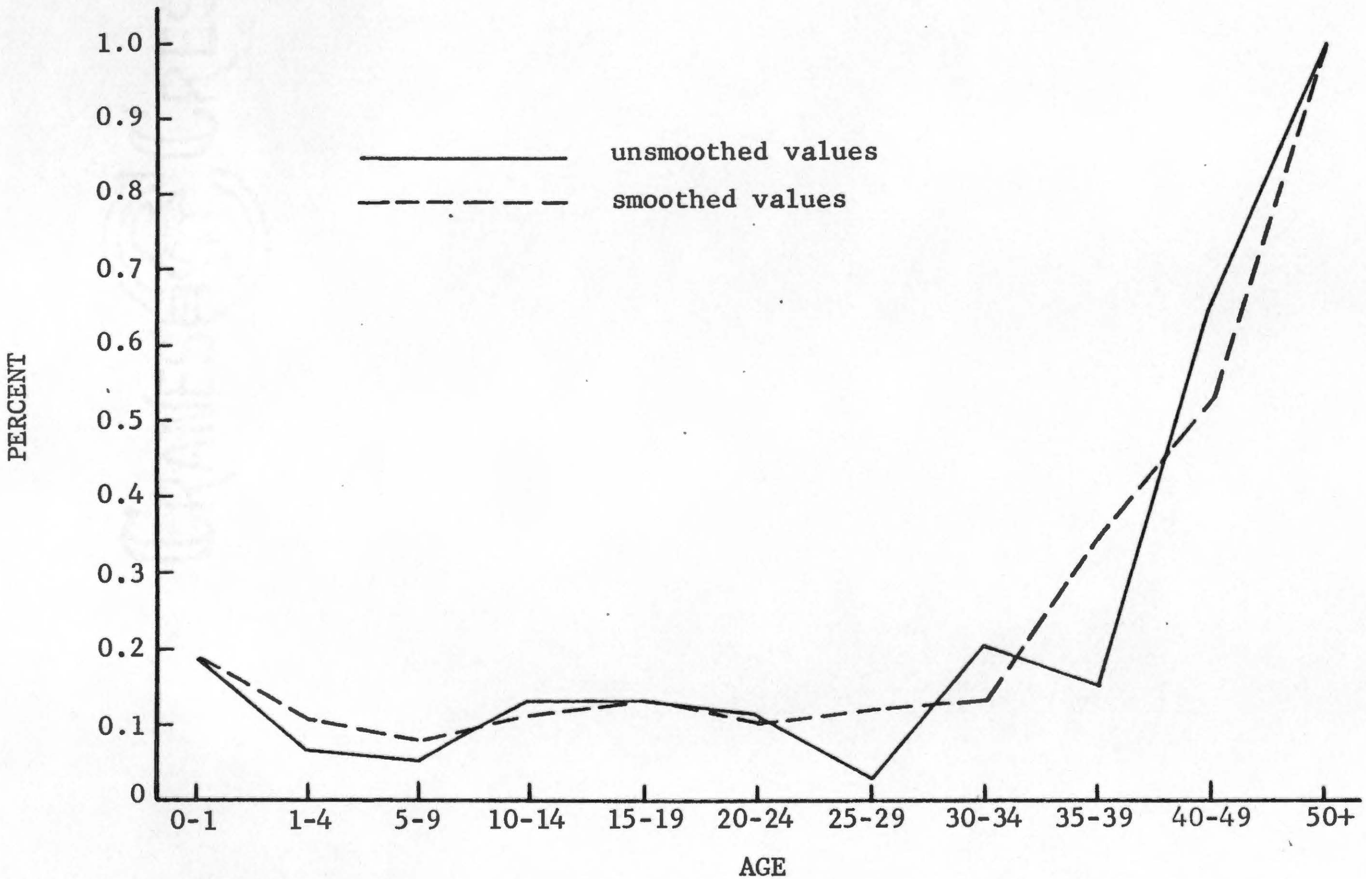


Figure 4. Probability of Death Curves (qx) For Combined Sex.

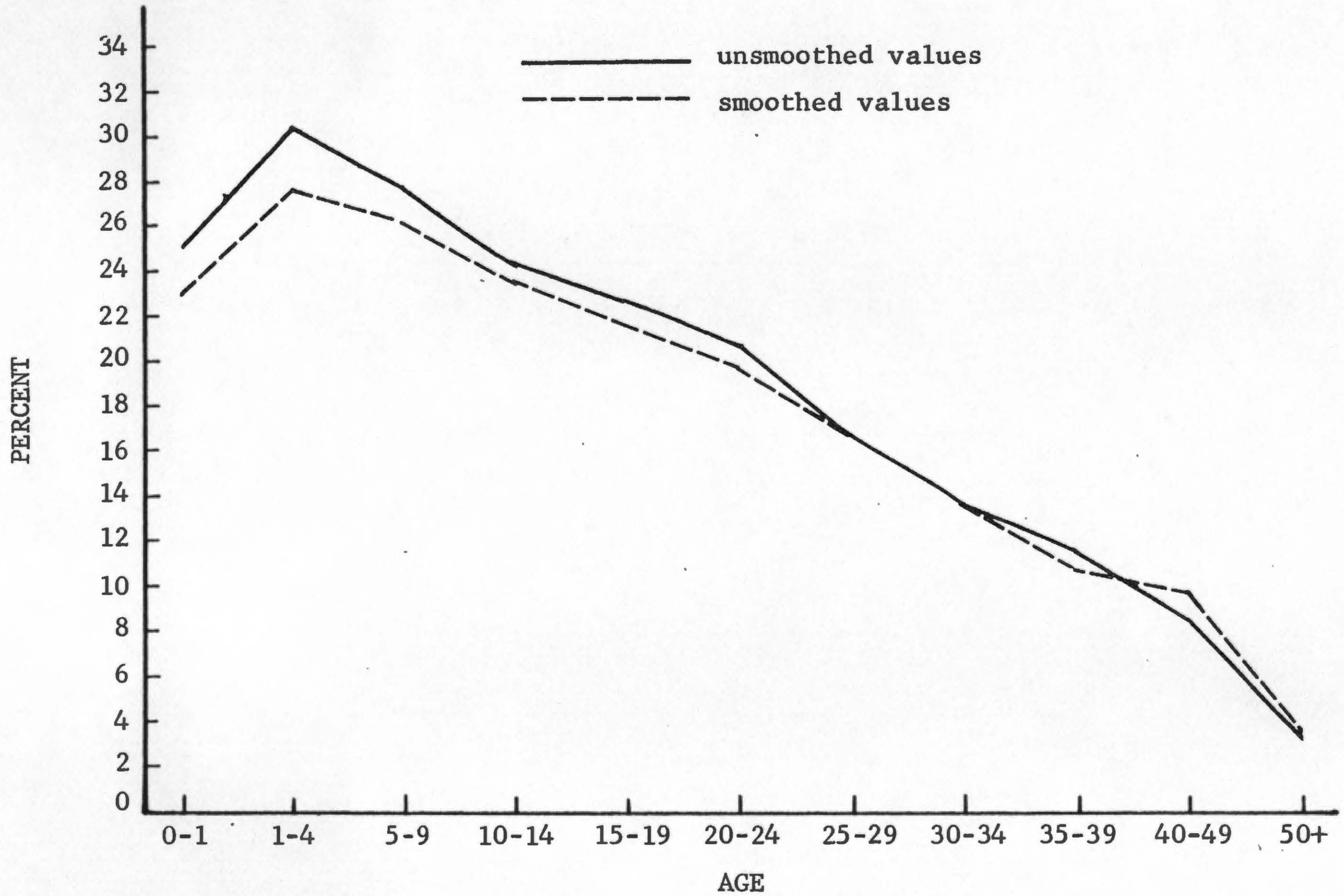


Figure 5. Life Expectancy Curves (e_x^o) For Combined Sex.

The Anderson mortality curve, dx, expresses the percent of people dying in each age interval. Smoothed values, (Figure 2), indicate that 19% of the deaths occur in infancy, a situation which probably reflects the problems associated with pregnancy, childbirth and the first year of life, as well as early selection because of congenital and developmental defects. Mortality drops to 6% by late childhood (5-9 years), and picks up slightly during adolescence This is especially true in the late adolescent years (15-19) and perhaps reflects the stresses associated with the assumption of adult activities, e.g., childbirth for females and hunting for males. The lowest mortality rates occur from young adulthood (20-24 years) through middle age (30-34 years). Mortality rates peak among older adults where the combined age categories, 35-50+, yield 34% of the deaths in the entire population. This pattern of relatively low infant/child mortality and high adult mortality is similar to that reported for several other skeletal populations (Lovejoy et al. 1977; Magennis 1977; Ubelaker 1974).

The inverse of the mortality curve is the survivorship curve, lx, which depicts the percent of the population surviving to each age interval. In Figure 3 the slope of the smoothed values rapidly decreases during the first five years of life with 71% of the population reaching the age of 5. Approximately one-half, 50%, of the population survives to 20 years of age, less than one-fourth, 22%, to 40 years, and about 10% to 50 years.

A more precise indicator of age-specific mortality is reflected in the probability of dying curve, qx. Because this statistic estimates the probability of dying in a given age interval, it provides a means to infer the differential effect of disease and death on age (Swedlund and Wade 1972:112; Palkovich 1978:117). The smoothed curve in Figure 4 shows that the probability of dying is highest in the older adult years (34% between 35-39 years and 54% between 40-49 years) and only moderate, 19%, in infancy (0-1 years). Not surprising is the greater chance of dying during late adolescence (approximately 14% between 15-19 years), than during any other intermediate age interval.

Another important vital statistic is life expectancy, e_x^o, which expresses the average number of years left to live at a given age. In Figure 5 the smoothed curve indicates a life expectancy at birth of approximately 23 years. If an individual survived the first year of life, he could expect to live another 27.6 years. A gradual decrease in life expectancy begins at 5 years of age where the value drops to 26.7 years. A person attaining the age of 20 could expect to live approximately the same number of years again; i.e., 19.7 years. By the age of 40, however, life expectancy is only another 9.6 years and by the age of 50, another 5 years.

Life expectancy at birth provides a standard means of comparing the relative health status and longevity of archaeological populations (Berryman 1981:67-68; Owsley and Bass 1979:150; Ubelaker 1974: 64). Table 5 provides values of life expectancy at birth for several comparative skeletal populations. The Late Mississippian Averbuch skeletal series from Middle Tennessee (Berryman 1981), the Late Woodland Libben series from Ohio (Lovejoy et al. 1977), and

Table 5. Life Expectancy at Birth in Several North American Skeletal Series.

Site	Date	Source	$\overset{o}{e}_x$
Averbuch	A.D. 1400	Berryman 1981	16.6
Libben	A.D. 800-1100	Lovejoy et al. 1977	19.9
Nanjemoy I	A.D. 1500-1600	Ubelaker 1974	20.0
Nanjemoy II	A.D. 1500-1600	Ubelaker 1974	22.9
Anderson	4770-3000 B.C.	Present Study	23.2*
Eva I/II	6000-3000 B.C.	Magennis 1977	25.9*
Cherry	2500-1000/500 B.C.	Magennis 1977	26.1*
Eva III	2500-1000/500 B.C.	Magennis 1977	33.8*

*Represents smoothed values.

the Nanjemoy series from Maryland (Ubelaker 1974) are used as benchmarks in the interpretation of population stress and its affect on life expectancy. Each of these represents large skeletal samples, the latter of which has ethnohistorical sources which support the demographic data. Lovejoy et al. (1977) considered the life expectancy at birth at the Libben site as representative of a robust, successful population. At Nanjemoy I and II, Ubelaker (1974:64) noted that life expectancy approximated that of Ancient Greece but not of populations from later periods in Europe, India, and the United States. In the present analysis, the Libben and Nanjemoy I and II sites are assumed to represent "average" conditions for aboriginal North American Indians; Averbuch is thought to represent a "stressed population" and is taken as such in this study (Berryman 1981; Gualiardo 1980, 1982).

Life expectancy is greater in the Anderson than in the Libben and Nanjemoy I series and is comparable to that of the Nanjemoy II Eva I/II, and Cherry series. If the Libben and Nanjemoy series represent "average" conditions, then the Anderson life expectancy value may reflect a relatively "healthy" population which was well-adapted to its local cultural-physical environment.

Crude Mortality Rate

Another important statistic for interpopulation comparisons is the crude mortality rate, m, which is calculated from the value of life expectancy at birth, where,

$$m = \frac{1}{\overset{o}{e}_{0-1}}$$

This function describes how many individuals died per 1000 per annum and directly reflects the overall life expectancy of a population (Ubelaker 1974:65).

As calculated from the smoothed value of life expectancy at birth (Table 4), the Anderson death rate is 43.1. Compared to other Amerindian skeletal series (Table 6), the Anderson death rate is higher than those of the Middle-Late Archaic Eva and Cherry populations but significantly lower than the Late Mississippian Averbuch population. The variation in the values of the Archaic populations may merely 'reflect differences in the completeness of the samples' (Ubelaker 1974:65), rather than meaningful differences in their respective mortality experiences. Again, the close agreement displayed in the crude mortality rates between the Anderson, Libben, and Nanjemoy II populations provides further support for the assumption that the Anderson population experienced relatively "average" conditions of mortality and longevity.

Table 6. Crude Mortality Rate for Several North American Skeletal Series[1]

Site	Location	Mortality Rate
Eva III[2]	Tennessee	30
Cherry[2]	Tennessee	38
Eva I/II[2]	Tennessee	39
Anderson	Tennessee	43
Nanjemoy II	Maryland	44
Nanjemoy I	Maryland	48
Libben[3]	Ohio	50
Averbuch	Tennessee	60

[1]Modified from Berryman (1981:70).

[2]Calculated from smoothed life tables in Magennis (1977:112-114).

[3]Calculated from the life table in Lovejoy et al. (1977:292).

VI. SUMMARY

Demographic data indicate that the Anderson skeletal series is representative of a relatively "healthy," well-adapted Middle Archaic population. Although mortality was "moderate" during the first year of life, 19%, an individual who survived this initial period could have expected longevity and good health to continue to at least 30-35 years of age. Survivorship data reveal that 22% of the population lived to be 40 years and at least 10% lived to be 50 years. Compared to other skeletal series, the Anderson series is "average" for life expectancy at birth and for its crude mortality rate.

As shown above, the life table is useful in organizing the age-at-death distribution of a skeletal population and in providing an insight into the group's longevity and mortality patterns. The causes of a skeletal population's morbidity and mortality patterns, however, are not found in the life table but may be inferred from an analysis of osteological indicators of nutritional and disease stress.

CHAPTER IV

LONG BONE GROWTH

Introduction

The health status of a human population measures its biological adaptive success to local environmental conditions. In studies of human population dynamics, the term "health" does not refer to a disease-free state, but to:

> . . . the state between constructive and destructive forces. It is never a lack of disease parasites, because such a state in biological terms is impossible. Some diseases . . . leave marks on bones; others do not. But all disease affects bone to some degree when it interferes with growth . . . (Angel 1975:177).

Recent clinical and epidemiological research in contemporary populations of known diet have established a relationship among the factors of linear growth retardation in children, protein and/or caloric malnutrition, and an increased susceptibility to disease and death (Aschcroft et al. 1966; Frisancho 1980; Frisancho et al. 1970a, 1970b; Jenkins 1981; Johnston et al. 1976 ; Martorell 1980; Martorell et al. 1975; Scholl et al. 1979).

Only a few corresponding studies in skeletal populations have used long bone growth as a measure of prehistoric health status. In three studies, the long bone lengths of child skeletons were compared to a modern sample of well-nourished Whites. Growth retardation in the prehistoric samples was attributed to a more rigorous environment and a genetic tendency toward shortness in the Late Archaic Indian Knoll population (Johnston 1962); caloric insufficiencies in the Western Eskimo and Aleut diet (Y'edynak 1976); and to the effects of infectious disease during the first year of life in child remains at the Late Woodland Libben site (Mensforth et al. 1978). In other studies, skeletal populations were compared to assess growth variation under different ecological conditions. Walker (1969) and Cook (1979) examined the adaptation to maize agriculture and its affect on long bone growth during the Woodland and Mississippian periods in Illinois. Finally, Jantz and Owsley (n.d.) assessed variations in long bone growth among temporally sequential Arikara populations of the Coalescent Tradition in South Dakota. The differences noted in bone lengths were attributed to fluctuations in the health and nutritional status of these populations as they responded to changing climatic conditions, socio-cultural deterioration caused by intertribal warfare and the effects of European contact (i.e., the acquisition of the horse, the introduction of epidemic diseases, and depopulation).

As Jantz and Owsley (n.d.) stated, skeletal growth studies are useful in reconstructing prehistoric lifeways. The limited application of long bone growth studies to other skeletal samples has been attributed to the methodological problems associated with this type of research (Buikstra and Cook 1980; Jantz and Owsley n.d.; Johnston 1968). The following is a discussion of these problems in relation to the Anderson skeletal sample.

Problems of Long Bone Growth Studies

The problems associated with long bone growth studies in skeletal populations were outlined by Johnston (1968:57-61) and further discussed by Jantz and Owsley (n.d.). Briefly summarized, these include: 1) sample size problems and the cross-sectional nature of the skeletal sample itself; 2) problems associated with the possibility that the subadults in the sample died from illnesses associated with growth retardation; and 3) problems associated with the possibility that estimated dental ages of the subadults may not correspond with their chronological ages. Inherent in all skeletal samples, these problems "must be borne graciously and realized analytically" (Johnston 1962:249).

Problem one is impossible to overcome in any skeletal sample. The Anderson series, like many Amerindian skeletal samples, is unquestionably small, especially in the late childhood and early adolescent age intervals (5-12 years). Buikstra and Cook (1980:450) noted that this limitation was circumvented in studies which focused on the long bone growth rates of infants and young children (Cook 1979; Johnston 1962). In addition, the cross-sectional nature of skeletal samples does not affect the viability of growth assessment so long as the limitations of this type of study are understood. Most important, a cross-sectional study estimates the average attained growth but does not reveal annual variations in any one individual's linear growth (Eveleth and Tanner 1976; Johnston 1980). Research among contemporary populations has shown that the "patterns" of growth provided in a cross-sectional study are efficacious in comparative studies of child growth (Birbeck and Lee 1973; Eveleth and Tanner 1976).

The second problem is also impossible to resolve in long bone growth studies since subadult skeletal samples are "clinical" by nature and cannot be assumed to represent the "normal, healthy population from which they were drawn" (Johnston 1962:249). The fact that juvenile remains are included in the sample suggests that growth retarding illnesses possibly caused early death. A partial solution to this problem is to assess the growth patterns and the vectors that affect them in contemporary "primitive populations existing under comparable conditions" (Johnston 1968:60). Evidence is now available on the health and disease patterns of modern hunter-gatherer groups still living in relative isolation (cf., Dunn 1968; Truswell and Hansen 1976). In general, the small size and low density of these groups, their mobile lifestyle, and their traditional well-balanced diet of animal, fish, nuts, and vegetable foods combine to provide adequate protection from malnutrition and starvation and from various types of density-dependent communicable diseases like syphilis, influenza, small pox, the measles, and the mumps. Chronic dietary deficiencies and their associated diseases are more likely to influence the growth patterns of sedentary agriculturalists who are dependent on a few staple crops which tend to be high in carbohydrates and low in protein, the essential nutrient for energy, bone metabolism and growth (Fabrega 1981; Newman 1975; Yudkin 1969). The different dietary conditions of hunter-gatherer and agricultural groups has been noted among neighboring !Kung groups of the Kalahari Desert wherein a nutritionally well-balanced diet was maintained by the nomadic groups and dietary deficiencies were noted in the groups who had recently settled in agricultural villages (Kolata 1974). In the proposed mode of subsistence for the Middle Archaic populations of Middle Tennessee (see Chapter II), it is probable that the diverse dietary resources provided at least minimum protein, carbohydrate, fat, mineral, and vitamin requirements essential for proper bone metabolism and growth. In addition, the exchange of foods and of individuals between neighboring groups would have also helped alleviate the effects of occasional food shortages.

It is also unlikely that the Anderson people were exposed to the types of communicable diseases which require dense, sedentary populations for transmission. The nature of the diseases which affected prehistoric hunter-gatherer groups is still a matter of conjecture but is thought to include the endemic infectious diseases known to be prevalent among contemporary hunter-gatherers, i.e., those caused by parasites and by zoonoses (Armelagos and Dewey 1970; Brothwell and Sandison 1967; Dunn 1968; Fabrega 1981; Fenner 1980; Polgar 1964; Wing and Brown 1979). Since it is debatable whether prehistoric disease patterns can be inferred by ethnographic analogy (cf., Armelagos and Dewey 1970; Dunn 1968; Johnston 1968; Lange 1980; Polgar 1964; Wing and Brown 1979; Wobst 1978; Yellen and Harpending 1972), the growth data for the Anderson children will be interpreted following the suggestion by Buikstra and Cook:

> At present it is perhaps wise to take a conservative stance and assume that data from diseased juveniles, whose linear dimensions may reflect terminal disease states and therefore represent a biased estimate for their cohort, represent minima rather than modal tendencies (1980:450).

Problem three represents the principal limitation in skeletal growth studies wherein stages of dental development are usually used as estimates of chronological age at death. For the most part this is a reasonable procedure since dental development exceeds skeletal development in correlation with chronological age, in resistence to environmental stress and in inter-individual stability (Garn et al. 1959; Keller et al. 1970; Lewis and Garn 1960). The principal concern in growth studies, however, is that different dental ageing standards (i.e., dental eruption vs. dental calcification rates), produce greater discrepancies in the growth patterns of a single skeletal population than the growth patterns of different skeletal populations when similar dental ageing standards are used (cf., Johnston 1962; Merchant and Ubelaker 1977; Sundick 1978; Ubelaker 1978). Caution must be exercised, therefore, in the selection of a reliable dental ageing standard. Merchant and Ubelaker (1977:68) discovered that White dental eruption standards (e.g., Schour and Massler 1941, 1944) overage Indian children and under-estimate their growth. Therefore, White dental calcification standards (Moorrees et al. 1963a, 1963b) may be "more reliable estimators of skeletal age," but these will also "overage Indian remains if their calcification rates differed from those of modern White children" (Merchant and Ubelaker 1977:71). Evidence for advanced rates of dental development was found by Owsley and Jantz (n.d.) in a sample of Arikara children. (See Chapter III for a discussion of this study.)

Discretion must also be used in selecting comparative long bone growth data. For example, Indian Knoll children displayed similar growth curves but depressed growth rates after 2 years of age when compared to a modern sample of "healthy" White children. Johnston (1962:252-253) attributed this situation to hereditary shortness and environmental stresses associated with a more rigorous lifestyle among the Indian population. Compared to a sample of protohistoric Arikara children, however, the Indian Knoll series displayed similar growth rates not only throughout childhood but on into adulthood as well (Merchant and Ubelaker 1977:70). This is significant since:

> . . . the two populations were distinct biologically, culturally and geographically, had very different subsistence patterns (hunter and gatherers vs. agriculturalists) and were separated by more than four thousand years (Merchant and Ubelaker 1977:70).

In summary, long bone growth studies may be more meaningful when comparisons are made with other Indian populations and when age estimates are based on dental calcification standards which "best" reflect the expected rate of mineralization for the skeletal population. For the present study, the Arikara dental calcification rates were used as estimators of skeletal age. (See Chapter III for a discussion of this ageing procedure and the assumptions concerning its utilization in other skeletal samples.)

Comparative long bone growth data, calculated by regression techniques, are also available for the Arikara populations used to develop these dental calcification rates (Jantz and Owsley n.d.). Basing their interpretation on detailed archaeological evidence and on ethnohistoric sources, these authors found that the Arikara growth rates were sensitive indicators of the differential effect that nutrition and disease had on these populations during their rapid transition from prehistoric to post-European contact times. Briefly summarized, adverse climatic conditions of the Neoboreal episode caused periodic food shortages which in turn caused a slight degree of growth impairment in the otherwise adequately-nourished Extended Coalescent populations who relied on a mixed horticultural/hunter-gatherer economy (Jantz and Owsley n.d.:9). An increase in linear growth among Postcontact Coalescent populations reflected the more stable and abundant food supply brought about by longer growing seasons and by the acquisition of the horse, the latter of which aided in an increased procurement of bison (Jantz and Owsley n.d.: 10). Growth rates again slightly decreased among Disorganized Coalescent populations wherein intertribal warfare, the introduction of epidemic diseases, and depopulation caused an increase in under-nutrition, morbidity and mortality (Jantz and Owsley n.d.:10).

In the present study it is assumed that comparison of the Anderson and the Arikara growth rates, which were developed from the same dental ageing procedure and regression techniques, provides a relatively equivalent basis on which to assess the health and nutritional status of the Anderson population. If the proposed dietary resources for Middle Archaic groups in Middle Tennessee provided at least the minimum nutrient requirements essential for the maintenance of sufficient bone metabolism and growth, then the Anderson children's growth rates should not differ significantly from the range of growth rates displayed by the Arikara populations, especially those characterized by an "adequate" or a "good" nutritional status, i.e., the Extended and the Postcontact Coalescent populations. These comparisons are made with the full understanding that variations in long bone growth are influenced by a more complex interaction of environmental and genetic factors than can be presented here. For the present study, however, environmental factors (i.e., infection, disease, and nutrition) are considered to be of primary importance during preadolescent growth and genetic factors to be more important during adolescent growth (Johnston et al. 1976; Sinclair 1968).

Methodology

An analysis of covariance statistical procedure which is available in the SAS package (SAS Institute 1982) and which is defined in Tatsuoka (1971) was used to compare the Anderson regression lines with those developed for the Arikara (Jantz and Owsley n.d.). Tests for equality of population regression slopes (i.e., equal growth rates), were conducted by inspection of the combined Type I Sequential Sums of Squares for the group*age and group*$\log_{10}$age interactions where group, age, and $\log_{10}$age were the independent variables. Tests of the adjusted means (i.e., the elevation of the regression lines, or more simply, equal means in long bone lengths when adjusted for differences on the covariate dental development), were conducted by inspection of the Type IV Partial Sums of Squares for the group main effect.

Long Bone Growth Rates of the Anderson Children

Long bone growth rates provide an indirect measure of the health and nutritional status, and therefore, the biological adaptive success of the Anderson population to its environment. As Howell noted:

> . . . mortality is the extreme of a process that also includes morbidity as a stage . . .
> The level of mortality that affects people at one age is highly correlated with the level of mortality at all other ages. The factors that cause mortality to be high in infancy cause high mortality in childhood, in adulthood, and in old age. When mortality conditions change, . . . they affect mortality at all ages (1973: 254-255).

No attempt was made to develop separate sex growth data since a reliable subadult sex estimator is not available. Any bias introduced into the growth data as a result of this procedure is expected to be minimal since dental development ages are thought to buffer against "different developmental chronologies between males and females" (Buikstra and Cook 1980:450).

Table 7 provides a chronological arrangement of the Anderson and Arikara skeletal samples compared in this analysis of long bone growth. Figures 6 through 9 graphically illustrate the regression lines for each long bone and provide the equations to predict bone length for a given dental age. Inspection of these regression lines

Table 7. Chronological Arrangement of the Skeletal Populations Used in the Analysis of Long Bone Growth*

Site	Date
Disorganized Coalescent (DC):	
Leavenworth (39CO9)	A.D. 1802-1832
Leavitt (39ST215)	A.D. 1784-1792
Postcontact Coalescent (PC):	
Four Bear (39DW2)	A.D. 1758-1774
Larson (39WW2)	A.D. 1679-1733
Sully E (39SL4)	A.D. 1675-1700
Mobridge 2 (39WW1)	A.D. 1675-1700
Extended Coalescent (EC):	
Sully A (39WW1)	A.D. 1663-1694
Sully D (39WW1)	A.D. 1650-1675
Mobridge 1 (39WW1)	A.D. 1600-1650
Rygh (39CA4)	A.D. 1600-1650
Middle Archaic (MA):	
Anderson (40WM9)	4770-3000 B.C.

*Modified from Jantz and Owsley (n.d.).

reveals several interesting patterns. First, the point of origin is relatively the same for all regression lines, regardless of long bone. In the lower limb bones, the Anderson regression line lies above those for the Arikara in early childhood but between the regression lines for the Postcontact and Disorganized groups after about 8 years of age (Figures 6 and 7). In the upper limb bones, the Anderson regression line is intermediate between those of the Disorganized and Postcontact groups in early childhood. In the humerus, however, the Anderson line merges with that of the Postcontact groups by 2 years of age and is above the lines of the other Arikara groups after 7 years of age. In contrast, the

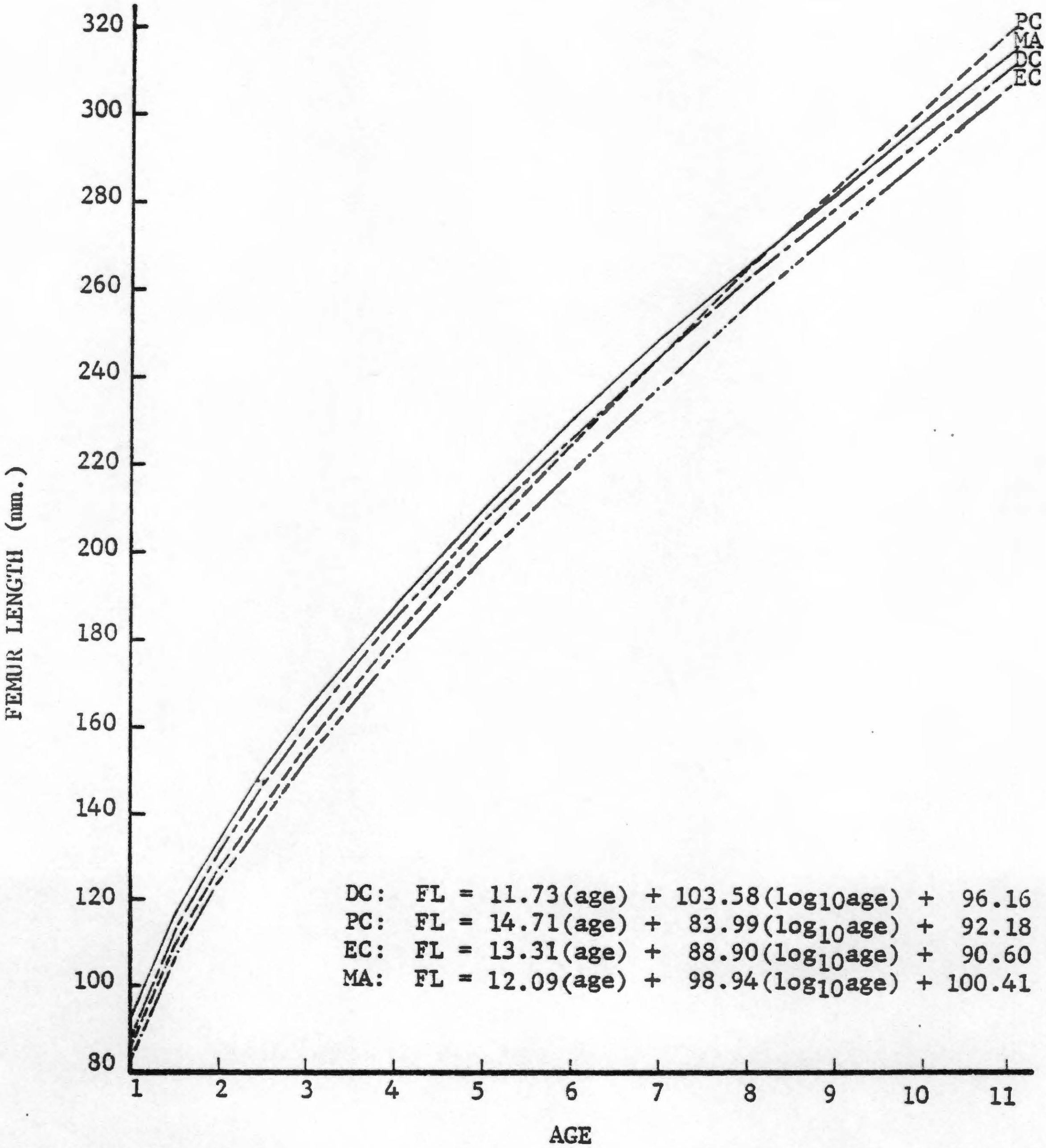


Figure 6. Comparison of the Anderson and Arikara Regression Lines For the Femur.

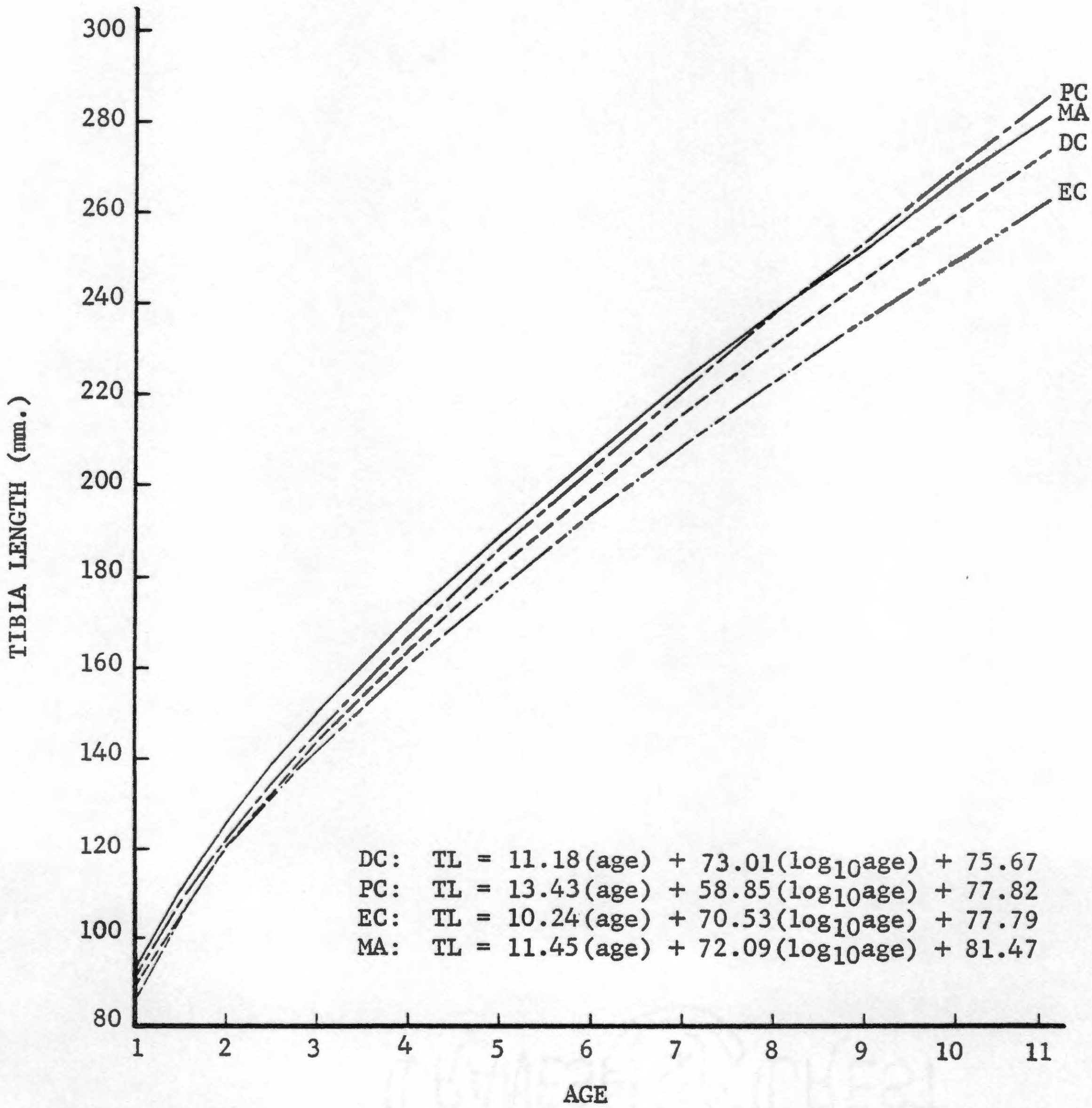


Figure 7. Comparison of the Anderson and Arikara Regression Lines For the Tibia.

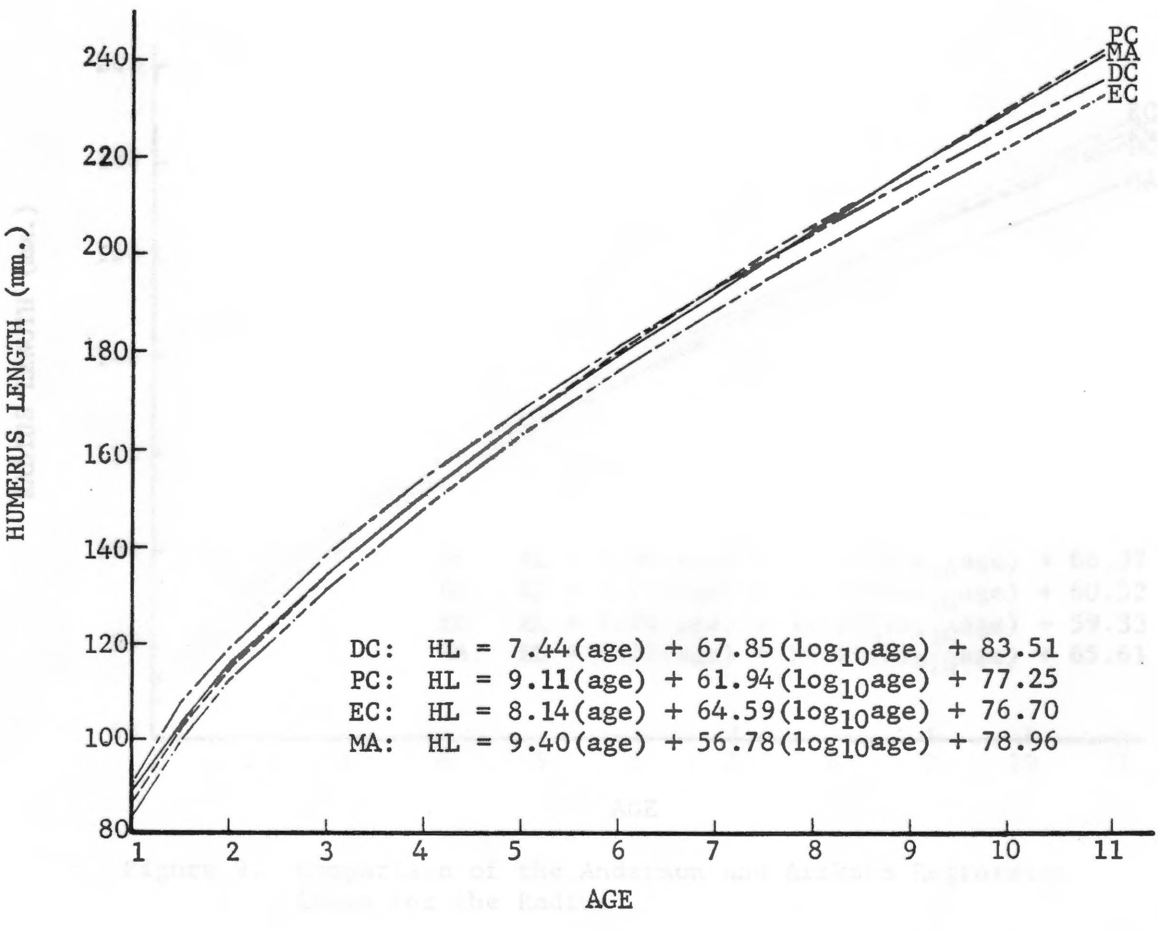


Figure 8. Comparison of the Anderson and Arikara Regression Lines For the Humerus.

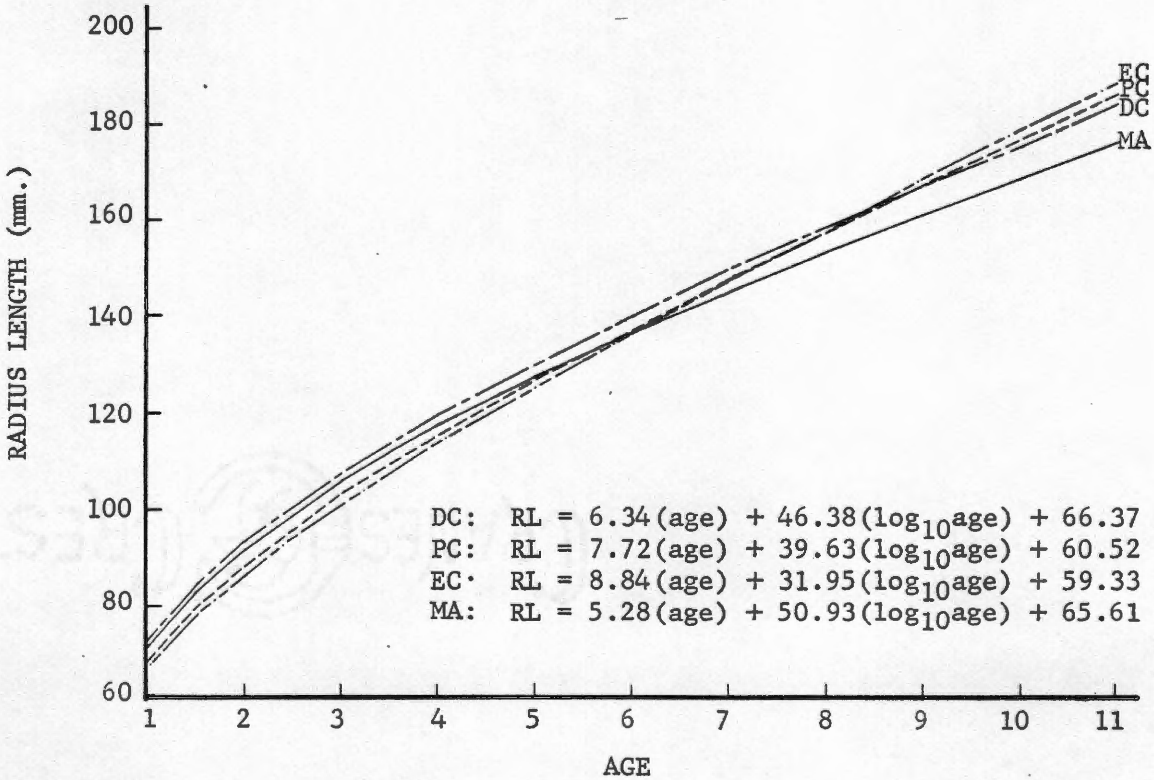


Figure 9. Comparison of the Anderson and Arikara Regression Lines For the Radius.

regression lines for the radius are characterized by a different pattern after 6 years of age when the Anderson line falls below those of all Arikara groups.

Table 8 presents the results of the analysis of covariance tests for slope homogeneity (i.e., equal growth rates). All of the F-ratios, except that for the radius in the MA/PC comparison, are nonsignificant. This means that the rates of growth are similar from 0.5 to 11.9 years of age. The significant F-ratio obtained in the test for MA/PC radial slope homogeneity is difficult to interpret because of the inconsistent growth patterns displayed by this bone for all of the comparative skeletal populations. Two possible explanations, however, can be offered for this anomaly. One possibility is that the radius is more sensitive to environmental stress than the other long bones so that the observed growth impairment in the radius is a more accurate reflection of the growth status of the Anderson children. However, a relationship between episodes of nutritional and disease stress and an increase in growth impairment of the radius have not been demonstrated in longitudinal radiographic studies of living children (Garn et al. 1968; Marshall 1968). A more probable explanation, is that, like most skeletal series, the small sample size of the older Anderson children (e.g., n=3 for all bones of children between 7 and 11.9 years), accounts for much of the variability represented in the radial slope. Indeed, when inspection is limited to the first five years of childhood as suggested by Buikstra and Cook (1980:450), similar growth patterns are discernable for all of the Anderson children's long bones.

Table 8. Analysis of Covariance Tests for Slope Homogeneity Among the Anderson and Arikara Skeletal Populations**

	MA/DC				MA/PC				MA/EC			
Source	df	SS	MS	F	df	SS	MS	F	df	SS	MS	F
Femur:												
Slopes	2	7.89	146.23	0.05	2	72.53	118.47	0.61	2	11.97	157.74	0.08
Error	78	11405.90			291	34473.80			146	23030.60		
Tibia:												
Slopes	2	2.79	128.76	0.02	2	22.12	107.47	0.21	2	95.39	110.28	0.86
Error	67	8627.00			260	27941.33			128	14115.33		
Humerus:												
Slopes	2	37.11	67.76	0.55	2	17.97	60.67	0.30	2	14.26	79.93	0.18
Error	76	5149.45			291	17655.60			145	11589.27		
Radius:												
Slopes	2	30.48	56.34	0.54	2	122.31	36.09	3.39*	2	137.68	49.26	2.79
Error	65	3662.22			242	8733.21			125	6157.71		

*$p < 0.05$.

**Sample Sizes: Note that the sample sizes for the Postcontact Coalescent groups differ from those in Jantz and Owsley (n.d.) since more subadults have been recently added to this category (Jantz, personal communication).

Femur: 11 (MA); 73 (DC); 286 (PC); 141 (EC)
Tibia: 10 (MA); 63 (DC); 256 (PC); 124 (EC)
Humerus: 13 (MA); 69 (DC); 284 (PC); 138 (EC)
Radius: 13 (MA); 58 (DC); 235 (PC); 118 (EC)

Given the above conditions, it is impossible to determine what factors were responsible for the aberrant growth pattern of the radius in the Anderson children. This isolated incidence of heterogeneous slopes, however, suggests that these unexplainable factors are not powerful enough to bias the present interpretation of long bone growth.

The comparative skeletal samples exhibiting nonsignificant regression slopes were further analyzed by testing for differences in mean long bone lengths when adjustment was made for the covariate dental development. The results of these tests are provided in Table 9 (note that the MA/PC adjusted means of the radius are included for completeness only and that the test result given here is meaningless). Again all of the obtained F-ratios are nonsignificant suggesting that there are no discernable differences in the mean long bone lengths of the Anderson and Arikara children.

The above findings are consistent with the prediction that the abundance and variety of plant and animal resources in the proposed Anderson diet provided adequate caloric and protein levels necessary for the maintenance of growth rates comparable to those of other Indian children characterized by "adequate, or even good nutritional balance," i.e., the Postcontact and Extended Coalescent groups (Jantz and Owsley n.d.:9-10). Support for this assumption comes from the low mortality rates noted for the Anderson children, a pattern unlike that expected for nutritionally deficient children.

> The mortality rate for children suffering protein caloric malnutrition is high, not only due to death from starvation, but also because the

Table 9. Analysis of Covariance Tests for Adjusted Means Among the Anderson and Arikara Skeletal Populations

	MA/DC				MA/PC				MA/EC			
Source	df	SS	MS	F	df	SS	MS	F	df	SS	MS	F
Femur:												
Means	1	356.31	142.77	2.50	1	33.75	118.15	0.29	1	467.82	155.77	3.00
Error	80	11421.68			293	34618.86			148	23054.54		
Tibia:												
Means	1	87.05	125.11	0.70	1	0.00	106.82	0.00	1	188.87	110.05	1.72
Error	69	8632.59			262	27985.58			130	14306.11		
Humerus:												
Means	1	61.68	66.97	0.92	1	5.72	60.38	0.09	1	93.96	79.03	1.19
Error	78	5223.68			293	17691.53			147	11617.80		
Radius:												
Means	1	1.18	55.57	0.02	1	158.64	36.79	4.31*	1	27.05	50.65	0.53
Error	67	3723.19			244	8977.83			127	6433.06		

*$p < 0.05$.

> malnourished child is more likely to die from childhood diseases from which normally nourished children recover (Wing and Brown 1979:35).

If favorable health and dietary conditions continued throughout the period of adolescent growth and into adulthood, then this should be reflected in adult long bone lengths as well.

Variation in Adult Femur Length

The estimation of adult stature is thought to represent the culmination of environmental factors which influence preadolescent growth and genetic factors which influence adolescent growth (Johnston et al. 1976). It is a well-known fact that long bone length and adult body height are correlated, but it is not known if the formulae for estimating stature of living Mongoloid and Mexican adults developed by Trotter and Gleser (1958:120) and by Genoves (1967:76) are applicable to North American archaeological samples, especially for the female remains (Ubelaker 1978:44). For this reason, the maximum length of the femur is taken to represent the "relative stature" of the Anderson adults.

Maximum morphological length was measured on complete femora only following the procedure outlined by Bass (1971:168). All measurements were taken on left bones whenever possible. The average maximum morphological femur length is 439.3 mm. for Anderson adult males and 402.7 mm. for adult females. Table 10 presents a comparison of these mean measurements with those of other archaeological populations, grouped by geographical area. Within these geographical divisions, the groups are homogeneous for

Table 10. Comparison of Maximum Morphological Femur Length (in millimeters) Among Various Skeletal Populations, Grouped by Geographical Area

		Males			Females		
Population	Date	N	Mean	S.D.	N	Mean	S.D.
Plains:							
Leavenworth[1]	A.D. 1802-1832	29	450.5	22.1	25	423.1	17.4
Larson[1]	A.D. 1679-1733	59	445.9	16.8	66	417.4	20.4
Mobridge 2[1]	A.D. 1675-1700	10	448.6	13.7	7	412.6	8.2
Mobridge 1[1]	A.D. 1600-1650	14	455.1	20.4	16	414.4	17.9
Rygh[1]	A.D. 1600-1650	8	449.9	13.7	4	408.8	24.4
Crow Creek[1]	A.D. 1325	44	442.0	23.2	41	407.5	15.5
Kaufman-Williams[2]	A.D. 1100-1800	23	448.1	23.5	24	413.9	15.5
Southwest:							
Pt. of Pines Late Population[3]	A.D. 1285-1400	31	437.7	21.1	39	403.3	25.1
Pt. of Pines Middle Population[3]	A.D. 1000-1285	37	426.5	16.4	37	398.8	21.2
Southeast-Mississippian:							
Averbuch[4]							
Cemetery 1	A.D. 1400	56	451.0	18.6	55	420.5	16.9
Cemetery 2	A.D. 1400	16	443.9	18.0	7	424.7	25.7
Cemetery 3	A.D. 1400	15	447.9	17.6	10	428.7	11.0
Toqua[5]	A.D. 1300-1600	43	443.0	17.5	37	415.0	17.8

Table 10 (continued)

Population	Date	Males N	Males Mean	Males S.D.	Females N	Females Mean	Females S.D.
Southeast-Archaic:							
Indian Knoll[6]	A.D. 500- 500 B.C.	255	439.5	20.8	192	412.7	17.6
Anderson	4770-3000 B.C.	6	439.3	19.3	7	402.7	22.0

[1] Willey (1982)

[2] Loveland (1980)

[3] Bennett (1973b)

[4] Berryman (1981)

[5] Parham (1982)

[6] Snow (1948)

their primary mode of subsistence: 1) Plains: mixed agriculture/hunting-gathering; 2) Southwest: agriculture; 3) Southeast-Mississippian: agriculture; and 4) Southeast-Archaic: hunting-gathering.

The mean femur lengths of these skeletal populations were compared by an analysis of variance statistical procedure defined by Neter and Wasserman (1974) where femur length was the dependent variable and group was the independent variable. An examination of the analyses of variance by sex for mean femur length is presented in Tables 11 and 12. The F-ratios in the first row of these tables indicate that mean femur lengths are significantly different ($p<0.001$) among all groups, regardless of geographical area. To identify the source of this variation the Among Groups effect was decomposed into Within Areas and Among Areas treatments. The F-ratios for differences in mean femur length Among Groups Within Areas show that virtually all areas, especially the Southeast subcategories, are internally homogeneous. The F-ratios of the Among Areas treatment, however, show significant differences ($p<0.001$) in mean femur length. A Bonferroni post hoc multiple comparison procedure (Neter and Wasserman 1974) was used to determine which areas differed in mean femur length. The results of these tests are presented in Tables 13 and 14. The nonsignificant F-ratios in Table 13 indicate that the mean femur lengths of the Southeast-Archaic males are similar to those of males in other geographical areas. In contrast, the mean femur lengths of the Southeast-Archaic females (Table 14) are similar to those of

Table 11. Analysis of Variance for Mean Femur Length of Adult Males

Source	df	SS	MS	F
Among Groups	14	23359.32	1668.52	4.22*
Among Groups Within Areas:				
Plains	6	2565.73	427.62	1.08
Southwest	1	2115.88	2115.88	5.35**
SE-Mississippian	3	1747.97	582.66	1.47
SE-Archaic	1	0.24	0.24	0.00
Among Areas	3	16929.50	5643.17	14.26*
Error	631	249631.55	395.61	
TOTAL	645	272990.87		

*$p < 0.001$
**$p < 0.025$

Table 12. Analysis of Variance for Mean Femur Length of Adult Females

Source	df	SS	MS	F
Among Groups	14	23743.71	1695.98	4.91*
Among Groups Within Areas:				
Plains	6	4552.34	758.72	2.20**
Southwest	1	384.49	384.49	1.11
SE-Mississippian	3	1837.31	612.44	1.77
SE-Archaic	1	675.38	675.38	1.96
Among Areas	3	16294.19	5431.40	15.74*
Error	552	190517.56	345.14	
TOTAL	566	214261.27		

*$p < 0.001$
**$p < 0.05$

Table 13. Bonferroni Post hoc Multiple Comparison Test of Mean Femur Length in Males Between Geographical Areas

Comparison	SS(L)	df	F
Plains v. Southwest	11822.61	1	29.88*
Plains v. SE-Mississippian	241.03	1	.61
Plains v. SE-Archaic	1656.00	1	4.19
Southwest v. SE-Mississippian	7920.10	1	20.02*
Southwest v. SE-Archaic	918.79	1	2.32
SE-Mississippian v. SE-Archaic	920.42	1	2.33

$^{*}F_{.05/6(1,631)} = F_{.005(1,631)} = 7.88$

Table 14. Bonferroni Post hoc Multiple Comparison Test of Mean Femur Length in Females Between Geographical Areas

Comparison	SS(L)	df	F
Plains v. Southwest	6666.72	1	19.32*
Plains v. SE-Mississippian	2279.76	1	6.61
Plains v. SE-Archaic	799.75	1	2.32
Southwest v. SE-Mississippian	14470.72	1	41.93*
Southwest v. SE-Archaic	884.45	1	2.56
SE-Mississippian v. SE-Archaic	3838.56	1	11.12*

$^{*}F_{.05/6(1,552)} = F_{.005(1,552)} = 7.88$

the Plains and Southwest females but are significantly different ($p < 0.005$) from those of the Southeast-Mississippian females.

These findings suggest that the Anderson males were as tall as males from other archaeological populations, regardless of their geographic or temporal distribution or their mode of subsistence. The Anderson females are characterized by the same pattern but are shorter than females of Late Mississippian populations in Tennessee. These results disagree with the general hypothesis offered by several authors that stature decreased as an adaptive response to the dietary shift from hunting-gathering to maize agriculture and to the concomitant increase in dietary deficiencies and disease-related selection forces (Cook 1972; Larsen 1982; Nickens 1976). In none of the present comparisons were the Archaic hunter-gatherer populations taller than the later agricultural groups; if anything, they were shorter. For example, mean femur length for the Late Mississippian groups is 446 mm. for males and 422 mm. for females; for the Archaic groups it is 439 mm. for males and 408 mm. for females. This amounts to an increase of 7 mm. for males and 14 mm. for females in mean femur length from Archaic to Mississippian times. Examination of the sexual dimorphism (calculated by the formula: male mean femur length - female mean femur length), for each time period shows greater sexual dimorphism among the Archaic populations ($\bar{X}_m - \bar{X}_f = 31$ mm.) than among the Late Mississippian populations ($\bar{X}_m - \bar{X}_f = 24$ mm.). This means that females showed a greater increase in height from Archaic to Mississippian times than did males and agrees with the significant difference noted in mean femur length for the Southeast Mississippian and Archaic females.

It is unlikely that the difference noted in relative stature between the Archaic and the Mississippian populations reflects either a more adequate diet with agricultural intensification as Bennett (1973b) suggested, or an increasing ability to "cope" with the nutritional deficiencies of an agricultural economic base as Nickens (1976) suggested. As Berryman (1981) illustrated, the Averbuch population was highly stressed, both nutritionally and socially, yet adult stature estimates were among the highest reported for North American archaeological populations. High stature estimates have also been noted among other Tennessee populations of the Late Mississippian period (Parham 1982; Ward 1972).

A possible explanation for the observed difference in mean femur lengths between the Archaic and Mississippian females is that an increase in stature did, indeed, occur between these periods and that the causes of this increase are similar to those which Frayer (1980) postulated for the Neolithic populations in Europe wherein a less rigorous sedentary agricultural lifestyle and more equivalent subsistence responsibilities between the sexes allowed females to attain their inherited growth potential. If similar selection pressures occurred among New World agriculturalists, then the significant increase in mean femur length of females from Archaic to Mississippian times may reflect a decrease in the functional demands made on the female body in a less rigorous agricultural lifestyle which allowed them to more nearly reach their inherited growth potential.

Boyce (1979) offered an alternative explanation for body size differences in populations from different environments. Although this model is presented in terms of animal populations, it suggests that body size is the result of selection factors associated with resource availability. According to Boyce:

> . . . large body size will be favored in seasonal environments . . . wherein . . . larger body size . . . enhances survival through periods of resource shortage . . . Large size may be envisioned as effectively buffering against the seasonality of the environment . . . (1979:576).

Functioning as a 'resource storage mechanism', large body size would have been adaptive in Mississippian populations whose primary dependence on maize as a food staple made them susceptible to seasonal food shortages when crops failed. In contrast, selection would have favored small body size among the Archaic hunter-gatherer populations who exploited a more predictable, diverse resource base. In terms of population fitness, resource availability is more likely to affect females since more of their resources are invested in reproduction. Therefore, in environments with low or unpredictable resource availability, selection would favor larger females so to "enhance survival for future reproductive attempts" (Boyce 1979:579). This agrees with the difference noted in relative height between Archaic and Mississippian females.

It is beyond the scope of the present study to pursue the differences noted in adult long bone lengths. Perhaps a more comprehensive analysis which included other subadult and adult long bones, especially from Woodland skeletal series, would provide a clearer picture of what happened in terms of growth and its relationship to mechanical stress and nutrition as populations shifted from a hunter-gatherer to an agricultural lifestyle in the Southeast.

<u>Summary</u>

Long bone growth rates, calculated by means of regression, were examined to assess the health and nutritional status of the Anderson population. The nonsignificant test results in the analyses of slope homogeneity and of adjusted means for the femur, tibia, and humerus indicated that the growth patterns of the Anderson children agree with the patterns of other Indian children characterized by either an adequate or a good nutritional status. The isolated case of significant slope heterogeneity for the radius was not considered important since the other tests on the radius were nonsignificant and since the radius has not proven to be a sensitive indicator of nutritional and disease stress in longitudinal radiographic studies of living children. Disregarding this anomaly, the Anderson long bone growth data were in accordance with the favorable nutritional conditions postulated for Middle Archaic inhabitants of the Nashville Basin and also agree with reports of the health and nutritional status of modern hunter-gatherer populations.

Additional insight into the growth status of the Anderson population was gained in an evaluation of adult mean femur lengths. In the analyses of variance by sex the mean femur lengths of both sexes were the same as those of the Late Archaic Indian Knoll adults.

Southeast-Archaic males were also similar in relative stature to males from later archaeological populations, regardless of their geographical location or mode of subsistence. The Southeast-Archaic females, however, were significantly smaller than females from populations of the Late Mississippian period in Tennessee. Whether this was caused by a more rigorous lifestyle among the Archaic hunter-gatherer populations which limited the females from attaining their inherited growth potential or whether it was due to other factors, such as selection favoring smaller body size under conditions of greater resource availability among the Archaic populations, is impossible to determine.

CHAPTER V

PATHOLOGY

I. INTRODUCTION

Disease states are widely recognized as a measure of the health status of prehistoric human populations (Brothwell and Sandison 1967; Buikstra and Cook 1980; Goldstein 1963; Morse 1969; Ortner and Putschar 1981; Sandison 1968; Ubelaker 1978; Wells 1964). Several recent 'population-based' studies have demonstrated that an examination of the age and/or sex distribution of the various disease processes manifest in a skeletal series can provide important information concerning the adaptive success of the population as well as aid in differential diagnosis and in the interpretation of mortality and longevity (Angel 1971, 1975; Cook 1976; Mensforth et al. 1978; Palkovich 1978). Differential diagnosis, however, is not always possible, or desirable, in many paleopathology studies because the bony response to many diseases is nonspecific (Morse 1969; Ortner and Putschar 1981; Sandison 1968; Ubelaker 1978). Erroneous diagnosis might also occur when postmortum bone changes and damage caused by such factors as soil acidity and moisture content, intrusive vegetation, rodent and insect activity, or even excavation techniques are confused with the affects that specific disease processes have on osseous tissue (Morse 1969; Sandison 1968; Ubelaker 1978). For these reasons, the examination of broad categories of disease processes which are known to affect bone in specific ways and the age and/or sex distribution of the individuals within these categories is considered to be a more reasonable approach in the examination of pathological conditions within the Anderson skeletal series.

II. METHODOLOGY

Eight broad categories were defined following the disease classifications in Morse (1969), Neumann (1967), Ortner and Putschar (1981), and Steinbock (1976). Every bone within the 73 burials was visually examined for the gross pathological alterations associated with these disease processes. (See Appendix C for a description of these diseases.) X-rays were made only on specimens with osseous modifications which could not be correctly classified by visual inspection.

As adapted from Palkovich (1978), skeletal lesions and defects were scored following the coding format presented in Appendix C wherein the type, state, and location of the pathology were recorded for each bone.

III. PATHOLOGY CONDITIONS ABSENT IN THE ANDERSON SKELETAL SERIES

Of the different types of pathology conditions listed in Appendix C, no skeletal evidence was found for traumatic dislocations, wounds caused by sharp instruments, exostoses, or for congenital vertebral or radial-ulnar fusions. Also absent were bone pathologies generally associated with Vitamin D deficiency, i.e., rickets and osteomalacia, or those associated with iron deficiency anemia, i.e., cribra orbitalia and porotic hyperostosis (Jaffe 1972; Morse 1969; Ortner and Putschar 1981; Steinbock 1976).

No observable pathologies were found in 28 burials, or 38% of the Anderson population. These burials included 13 infants (0-1 years), 7 children (1-9 years), 4 adolescents (10-14 years), a 21 year old female (B59), and the 3 adult cremations (B31, B53, B73).

IV. PATHOLOGY CONDITIONS PRESENT IN THE ANDERSON SKELETAL SERIES

The frequency of osteopathologies found in the Anderson skeletal series is presented in Table 15. Age categories were defined in 10-year intervals to provide a more reasonable basis on which to interpret the incidence of pathological conditions in the age intervals with small sample sizes (e.g., see ages 25-29 in Table 3). The presence of bone pathologies in the four adult burials with inexact age estimates (B30, B37, B62, B69) were distributed between adjacent adult age intervals. In this procedure the distribution of affected adults with estimated ages was determined for each disease category. The number of affected adults within each age interval was then divided by the total number of adults over 30 years of age. This percentage was then multiplied by the number of affected adults with inexact age estimates and the product was added to each respective age interval. This procedure assumes that adults of unknown or inexact age have the same general distribution of pathologies as adults with estimated ages. Figure 10 displays some of the pathologies noted in the Anderson skeletal remains.

Table 15. Pathology Conditions Present in the Anderson Skeletal Series[1]

Age Interval	Number of Individuals	Fractures	Crushing Injuries	Other Types of Trauma	Osteo-myelitis	Primary Periostitis	Other Infectious Diseases	Neural Arch Defects	Solitary Bone Cysts	Degenerative Arthritis	Abscesses	Antemortum Tooth Loss	Carious Lesions
0-9	21.0	--	--	--	--	2	--	--	--	--	--	--	--
		--	--	--	--	.10	--	--	--	--	--	--	--
10-19	13.0	5	--	1	1	2	1	2	--	--	1	1	1
		.38	--	.08	.08	.15	.08	.15	--	--	.08	.08	.08
20-29	5.5	2	--	--	--	1	--	--	1	1	4	1	--
		.36	--	--	--	.18	--	--	.18	.18	.72	.18	--
30-39	10.8	4.6	1	1	2	3.4	1	--	--	9.3	4	6.6	--
		.43	.09	.09	.19	.31	.09	--	--	.86	.37	.61	--
40-49	15.1	5.8	--	3	--	--	--	1	--	12.8	8	8.8	--
		.38	--	.20	--	--	--	.07	--	.85	.53	.58	--

Table 15 (continued)

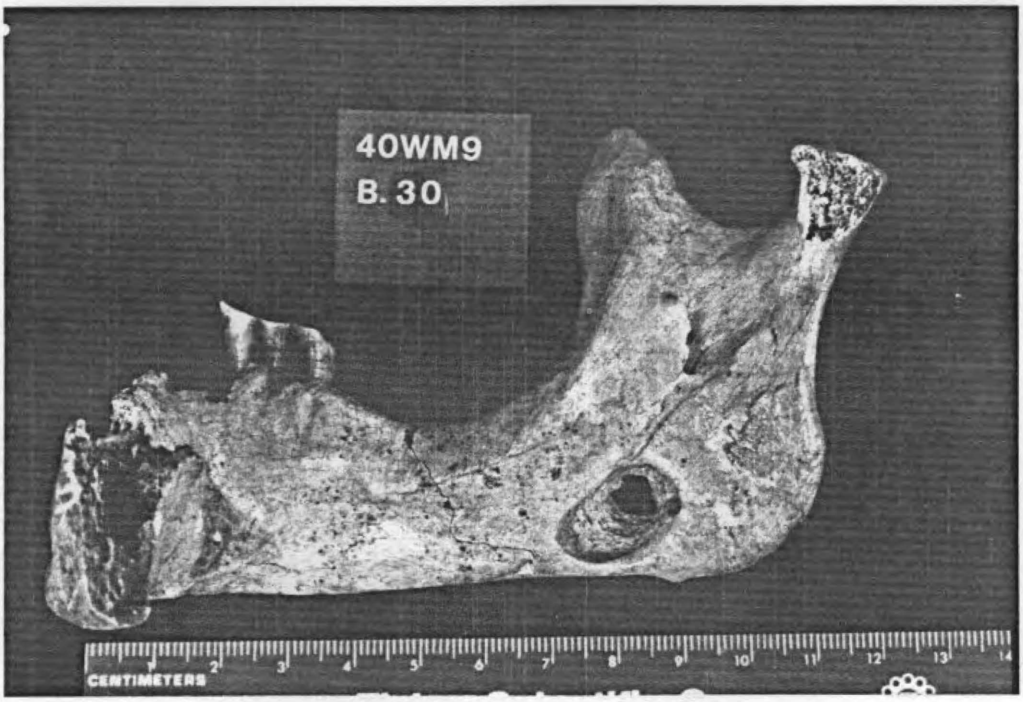
Age Interval	Number of Individuals	Fractures	Crushing Injuries	Other Types of Trauma	Osteo-myelitis	Primary Periostitis	Other Infectious Diseases	Neural Arch Defects	Solitary Bone Cysts	Degenerative Arthritis	Abscesses	Antemortum Tooth Loss	Carious Lesions
50+	7.6	4.6	--	--	1	4.6	--	--	--	5.9	5	5.6	--
		.61	--	--	.13	.61	--	--	--	.78	.66	.74	--
TOTAL[2]	73.0	22	1	5	4	13	2	3	1	29	22	23	1
		.30	.01	.07	.05	.18	.03	.04	.01	.40	.30	.32	.01

[1]The top line in each category represents the number of affected individuals and the second line represents the number of affected individuals divided by the total number of individuals within the age interval.

[2]Total number of individuals affected by a disease is listed in the top line and the bottom line represents the total number of affected individuals divided by the total sample size (N=73).

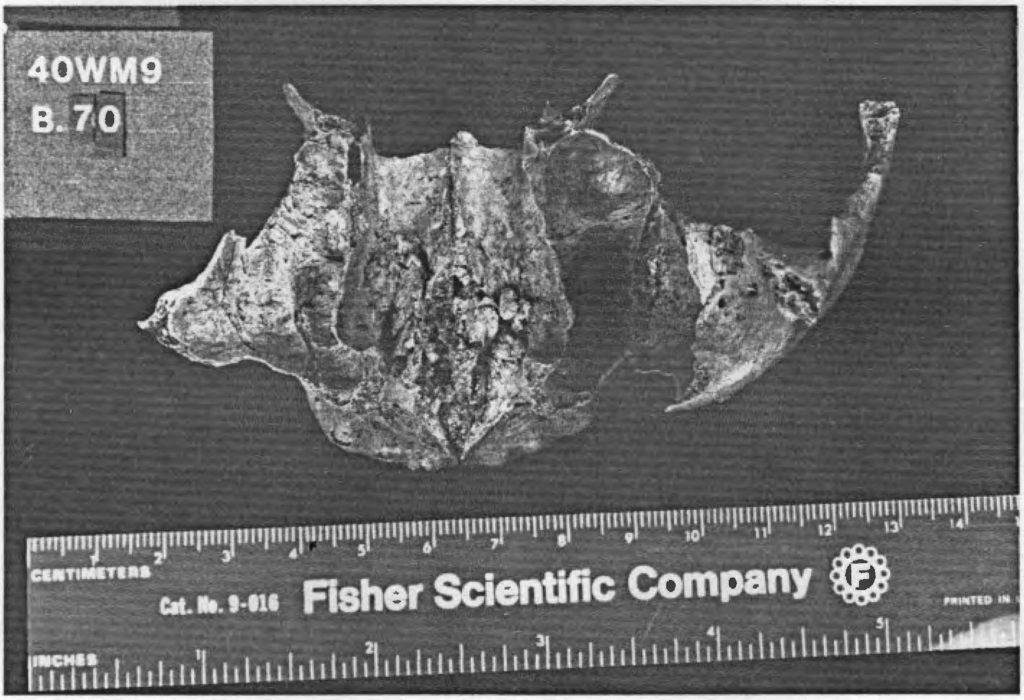
Figure 10. Representative Pathologies Noted in the Anderson Skeletal Remains.

Among the pathologies found in the Anderson burials were: (A) Mandibular cyst, dental attrition, and antemortum tooth loss with alveolar bone resorption; (B) dental wear, apical abscess, antemortum tooth loss with alveolar bone resorption; (C) Inflammation of the nasal cavity, suggesting pronounced upper respiratory infection; (D) Degenerative arthritis of the knee joint expressed as lipping, porosity and eburnation.



(A)

(B)


40WM9
B.70
CENTIMETERS
Cat. No. 9-016
Fisher Scientific Company
INCHES

(C)


40WM9
B.71
Fisher Scientific Company

(D)

Trauma

Pathologies reflecting traumatic conditions were found in 24 individuals, or 33% of the Anderson skeletal series. The sex distribution of these pathologies included 13 males, 10 females and one adult, sex indeterminate. The primary types of trauma included fractures of long and short bones, the ribs, and the mandible; collapsed vertebrae; and one case of crushing injuries.

Fractures were evident in 30 bones of 22 individuals of which 7, or 32%, were 15-29 years of age and 15, or 68%, were older than 30 years of age. The incidence of fractures was greater in males (11 or 79%) than in females (10 or 42%). One fracture was located in an adult of indeterminable sex. Of the 30 fractures, 6 were in the state of healing, 23 were well-healed, and one showed no sign of healing the time of death.

Slightly more than one-half (53%) of the fractures occurred in the long bones of the shoulder and upper limb. One of these fractures (B3, right clavicle) represents the single incidence of nonunion (pseudarthrosis). It is unlikely that this false joint resulted in disability since it was well-healed and had none of the traits associated with unsatisfactory unions like shortening, angulation, or rotation deformities (Baetjer and Waters 1921:85; Morse 1969:5). Secondary arthritis in the form of osteophytosis (marginal lipping), and rarefaction (porosity), were present on the joint surfaces of 9 of these bones.

Eight fractures involved 4 ribs, 2 fifth metatarsals, 2 fibulae, and the body of a mandible. All of these fractures were well-remodeled, exhibited relatively good alignment, and probably did not cause disability.

Compression fractures were evident in 9 individuals, 5 (or 36%) males and 4 (or 17%) females. Of these, 7 were in lumbar vertebrae, 5 of which were in individuals 30 years or older. These were well-healed and resulted in osteophyte formation on adjacent vertebral bodies, signs of which suggest survival after the injury. In one young male (B18), a compression fracture occurred in the fourth lumbar vertebral body and radiated posteriorly to include the entire vertebral arch of the right side, the latter of which exhibited signs of healing at the time of death. In another young male (B52), a compression fracture of the first lumbar vertebra caused lateral angulation and slight osteophytosis of the other lumbar vertebrae. It is likely that the same force that caused this fracture also herniated the vertebral discs between the L3/L4 and L4/L5 joints (Bruce Bradtmiller, personal communication). Considerable pain, discomfort, and disability may have resulted from these lesions.

The remaining incidences of compression fractures occurred in the lower thoracic vertebral bodies of two young females. In one, (B14), the fractured tenth thoracic vertebral body exhibited signs of healing at the time of death as well as slight osteophyte formation between the T9/T10 vertebral bodies. A compression fracture on the twelfth thoracic vertebral body in B10a, however, showed no signs of healing, suggesting the individual died shortly after the injury.

Crushing-type injuries occurred in one adult female (B29) and are suggestive of a fall on the left side which possibly occurred during late adolescence (Bruce Bradtmiller and Doug Owsley, personal communication). These pathologies include compression of the left humeral head during its fusion to the diaphysis, causing its posterior-inferior displacement and the exposure of erratic bone along the former growth plate, the latter of which is normally covered by the humeral head following fusion. The greater trochanter of the left femur also sustained a crushing injury which resulted in bone destruction and pronounced secondary osteophyte formation. Midshaft fractures also occurred on the left ulna and left radius. The small size of the left humerus and left clavicle suggests that these injuries resulted in differential use of the left arm. In addition, compression of the anterior portion of the third lumbar vertebral body probably resulted in lateral angulation of the vertebral column. According to Ortner and Putschar (1981:56) this type of injury is usually caused by a "sudden excessive impaction."

Skeletal evidence for other types of traumatic conditions was found in five individuals. In four of these individuals, the pathologies are suggestive of "stubbed toes." In the other individual (B55), a bone chip (20 x 16 mm.) had been removed from the medial surface of the left tibial diaphysis and replaced at a right angle to its original position so that the chip was slightly elevated above the shaft. Callous formation on the shaft suggests early stages of healing at the time of death. Nothing abnormal was apparent on the radiograph of this specimen.

Infectious Diseases

Inflammation of the bone is usually classified as periostitis--inflammation of the periosteum, and osteomyelitis--inflammation of the medullary cavity (Morse 1969; Ortner and Putschar 1981; Steinbock 1976). These disease conditions are common in prehistoric populations; the high incidence of which may reflect infectious disease-related selection pressures which were present in the population. According to Ortner and Putschar:

> In human populations of antiquity, generally about half the individuals born died during infancy and childhood. The major cause of this mortality was infectious disease, but trauma becomes increasingly significant. Even among hunters and gatherers living today, infection of the digestive system results in the death of many of the infants and children (1981:104).

Osteomyelitis is usually caused by infection with a pyogenic (pus producing) bacteria introduced into the bone by trauma or through the bloodstream (Morse 1969:17; Ortner and Putschar 1981:105; Steinbock 1976:60). The less severe condition, periostitis, usually results from either overlying soft-tissue infections or from traumatic fractures or other types of injuries. In this analysis, periosteal bone reactions do not include fractured bones. These specimens were included in the foregoing disease category.

Skeletal evidence of mild osteomyelitis was found in four individuals, including a young adolescent, two middle-aged males, and an old female. In three of these individuals, radiographs of a left humerus (B28), a right ulna (B55), and a right tibia (B56), showed thickening of the subperiosteal bone and narrowing of the medullary cavities. The gross morphology of these specimens, however, showed well-remodeled periosteal surfaces with no sequestra or abscess formation, indicating that the infectious conditions were well-healed at the time of death. In the fourth individual (B38), however, an active case of mild osteomyelitis on the anterior surface of the left femur may have contributed to the individual's death.

More common in the Anderson people was the occurrence of periostitis. Found in 13 individuals, or 18% of the population, this condition was slightly more frequent in females (7, or 29%) than in males (3, or 21%), and more frequent in adults (10, or 26%) than in subadults (3, or 9%). Localized periostitis, i.e., single bone involvement, occurred in six individuals. Evidence of active widespread periostitis, i.e., multiple bone involvement, occurred in six other individuals, and one well-healed case of widespread periostitis was found on the tibiae of a small infant (B57). The gross morphology of this infant's bones showed considerable symmetrical swelling of the diaphyses but no evidence of lytic lesions. A radiograph of these specimens showed periosteal bone thickening with no involvement of the underlying bone cortex or medullary cavity (Bruce Bradtmiller, personal communication).

Lesions suggestive of other types of infectious diseases were found in two females. In one (B32), porosity of the endocranial squamosal surfaces of the temporal bones suggests that some type of middle ear infection was active at the time of death (Bruce Bradtmiller, personal communication). In the other individual (B70), pronounced bone destruction with lytic lesions occurred on the base of the nasal aperture (see Figure 10-C). This may have resulted from a severe case of upper respiratory infection with a secondary response in the underlying palatal region (Bruce Bradtmiller, personal communication).

Congenital Defects

The only type of congenital defect found in the Anderson skeletal series involved neural arch defects. These included a case of spina bifida occulta (B14), and separate neural arches in the fifth lumbar vertebrae of two individuals (B18, B71). According to Morse (1969:30) these types of congenital defects are "inconsequential" and rarely cause disability.

Tumors

A well-defined cyst (18 x 12 mm.) was found on the body of a mandible in a young male, B30 (see Figure 10-A). Morse (1969:146-147) noted similar cysts among the Late Archaic Robinson skeletal series from Smith County, Tennessee. It is not known whether these cysts are due to trauma or to some other pathological condition.

Degenerative Arthritis

Degenerative arthritis, or osteoarthritis, is a pathological condition produced by the gradual erosion of articular cartilage, abrasion of articular surfaces, and the formation of new bone on articular margins (Brothwell and Sandison 1967; Ortner and Putschar 1981; Steinbock 1976; Ubelaker 1978). Skeletally these changes appear as slight rarefaction (joint surface pitting) and osteophytosis (marginal lipping) in mild arthritic cases and pronounced pitting and lipping with possible eburnation (joint surface hardening and polishing) in extreme arthritic cases (Ortner and Putschar 1981; Ubelaker 1978).

Although many systemic factors contribute to arthritic changes, including those associated with the normal process of ageing, heredity, and hormonal changes, the most important factor in archaeological populations may be mechanical-functional stress associated with a particular subsistence pattern (Jurmain 1977, 1980; Ortner 1968; Ortner and Putschar 1981). For example, Ortner (1968) and Jurmain (1977) suggested that a rigorous lifestyle possibly contributed to the greater frequency of degenerative arthritis among Eskimos than among other Indian groups, or among American Whites and Blacks. In another study, Larsen (1982) found that the shift from a hunting-gathering to a sedentary agricultural lifestyle among temporally sequential groups living along the Georgia coast was associated with a significant decrease in degenerative arthritis. An agricultural lifestyle was assumed to require less time and less work, thereby placing less mechanical-functional demands on the body. Also noted were sex-related differences in the frequencies and the distribution of degenerative arthritis, regardless of subsistence pattern:

> Males of both the preagricultural and the agricultural groups reflect male hunting responsibilities in that they exhibit more stress-related degenerative joint changes than do females in either of the groups (Larsen 1982:227).

The intent of the present analysis is to investigate the age and sex distribution of degenerative arthritis in the Anderson skeletal series. A procedure similar to that proposed by Larsen (1982:189-190) was utilized to record the presence of degenerative arthritis expressed as either pitting, eburnation, or marginal lipping, or by a combination thereof in the major postcranial articular joints: vertebral, shoulder, elbow, hip, and knee. Figure 10-D illustrates a case in which these three conditions were found on the articular bone surfaces of the left knee in Burial 71.

Table 15 lists the distribution of the age-related frequencies of degenerative arthritis in the Anderson adults. These frequencies represent the number of individuals (combined sex), not the number of joints, affected by arthritis. The incidence of degenerative arthritis rapidly increases from only 18% in the 20-29 age interval to greater than 75% in the remaining adult age intervals.

A more detailed examination of the presence of degenerative arthritis is presented in Table 16. The frequencies listed reflect the number of individuals affected by arthritic changes in the particular joint area, regardless of side of body or of the number of bones affected within a given joint. The results show that males have greater frequencies of degenerative arthritis than females in all articular joints. In males the elbow shows the most involvement followed by the cervical/knee combination, and then by the lumbar, shoulder and finally the thoracic/hip combination. Females show a relatively similar pattern of involvement except that the hip and elbow show the highest frequencies. The greater frequency of degenerative arthritis in males may reflect the more mechanically stressful subsistence activities assumed by men in a hunter-gatherer society (Larsen 1982). It may also reflect a generally older age attained by males in this population as Jurmain (1980) has suggested for prehistoric populations in general.

Table 16. Male-Female Comparison of Degenerative Arthritis in the Anderson Adults

Joint	Males N[1]	Males %[2]	Females N[1]	Females %[2]	Sex Indet. N[1]	Sex Indet. %[2]	Total N	Total %[3]
Vertebral:								
Cervical	8	67	7	33	-	--	15	38
Thoracic	5	42	4	19	-	--	9	23
Lumbar	7	58	7	33	1	17	15	38
Shoulder	6	50	6	29	1	17	13	33
Elbow	9	75	8	38	1	17	18	46
Hip	5	42	8	38	1	17	14	36
Knee	8	67	7	33	1	17	16	41

[1]Number of affected individuals.

[2]Number of affected individuals divided by the total number of males (N=12), females (N=21), or sex indeterminate (N=6), respectively.

[3]Total number of affected individuals, sex combined, divided by the total adult sample over 20 years of age (N=39).

In the total adult sample, the elbow and knee are the most frequently affected joints followed by the lumbar/cervical combination. This pattern is contrary to that found in modern populations wherein the hip and knee are more frequently affected by degenerative arthritis (Jaffe 1972; Jurmain 1977; Ortner and Putschar 1981). Jurmain (1980:148) has suggested that a greater involvement in the elbow may reflect "culturally patterned functional stress."

In summary the incidence of degenerative arthritis became more prevalent in the Anderson adults after the age of 30. Males were more affected than females, perhaps reflecting the more mechanically stressful demands of hunting activities.

Dental Disease

Dental lesions were another common pathological condition in the Anderson people (see Figure 10-A and 10-B). Data were recorded for abscesses, antemortum tooth loss with resorption of the alveolar bone, and carious lesions. Table 15 presents the age distribution of these pathologies. The frequencies are reported for the number of affected individuals in each age interval rather than for the total number of abscesses, lost teeth, or caries. In general, the incidence of both abscesses and antemortum tooth loss increases with age. It is interesting, however, that both conditions are evident at a relatively young age (10-19 years) and that the greatest frequency of abscesses occurs in the 20-29 age interval. In all cases, abscesses and tooth loss were accompanied by marked dental wear which caused both the exposure of secondary dentin and of pulp cavities in many teeth. Varying degrees of interproximal attrition were also present, especially in the posterior dentition. Each of these pathologies, i.e., abscesses, tooth loss, attrition, and the exposure of secondary dentin and pulp cavities, are common features in other archaeological skeletal remains (Ortner and Putschar 1981). Although it is impossible to determine the causative factors of these dental lesions, it is likely that the abrasive diet of the Anderson people (i.e., the consumption of large quantities of gastropods), caused extreme tooth wear which in turn caused abscessing and the subsequent exposure of secondary dentin and pulp cavities. A similar trend in tooth wear was observed in the Late Archaic Indian Knoll people who "subsisted upon fresh water clams" (Snow 1948:501).

The sex distribution of these dental pathologies (Table 17) indicates that males are more affected than females. It is not possible, however, to make any statement concerning this distribution since many adult burials were too fragmented for an assessment of dental pathologies.

In contrast to the above findings, only one carious lesion occurred in the center of a right mandibular second molar of an 11 year old child (B33). Another cavity possibly occurred in the buccal groove of the same tooth. It is possible that caries were present in other individuals but the breaks noted in their teeth

Table 17. Male-Female Comparison of Dental Pathologies in the Anderson Adults

Pathology	Males N[1]	Males %[2]	Females N[1]	Females %[2]	Total N	Total %[3]
Abscesses	10	71	12	50	22	42
Antemortum Tooth Loss	11	79	12	50	23	44

[1]Number of affected individuals.

[2]Number of affected individuals divided by the total number of males (N=14) and females (N=24), respectively.

[3]Total number of affected individuals (sex combined) divided by the total sample size in age intervals 10+ years (N=52).

made it difficult to determine whether they were caused by caries or by some type of fracture, either caused antemortum or postmortum (Ortner and Putschar 1981:453). The low incidence of caries in the Anderson skeletal series is similar to that noted in other preagricultural populations. It is thought a reliance on corn, which is high in sucrose, as a dietary staple promoted a significant increase in caries among archaeological populations who adopted an agricultural lifeway (Larsen 1982; Turner 1979).

Summary

The most common pathology conditions found in the Anderson skeletal sample were those associated with degenerative arthritis, trauma, and dental disease. Sex- and age-specific distributions show a greater incidence of degenerative arthritis with increasing age and a greater incidence in males than in females. The elbow, knee, cervical and lumbar joints were more frequently affected in males; the elbow and hip in females. It was suggested that the higher incidence of affected males possibly reflects the more mechanically stressful demands associated with hunting activities.

Fractures were the most common type of traumatic condition occurring with fairly even distributions throughout adolescence and adulthood. No fractures, however, were found in the 0-9 age interval. A greater frequency in old adults (50+) probably reflects "senile osteoporosis and other morbid conditions which generally increase the vulnerability of the skeleton to trauma" (Ortner and Putschar 1981:55). Most fractures were adequately healed and all showed good alignment.

Dental disease was another common problem in the Anderson people. The incidence of abscesses and antemortum tooth loss generally increased with age and was associated with marked dental attrition which often caused the exposure of secondary dentin and pulp cavities in many of the teeth. These pathologies were attributed to excessive dental stress caused by an abrasive diet.

Infectious diseases did not appear to pose a serious problem to the Anderson people. In most instances the infectious reaction was confined to a localized area on a single bone. Generally occurring more often in females than in males and more often in adults than in children and adolescents, most periosteal surfaces were well-healed at the time of death.

CHAPTER VI

SUMMARY

The primary objective of this study was to provide a comprehensive biological analysis of the skeletal remains from the Anderson site in order to better understand the nature of Middle Archaic populations in Middle Tennessee. Demographic, long bone growth, and pathology data were investigated in light of the problems associated with archaeological skeletal samples in general and with the Anderson sample in particular. Like other Archaic skeletal samples, the Anderson series could not be considered a "total" population. This was attributed to the shifting settlement-subsistence pattern of these people as well as to an incomplete recovery of the site. In addition to these problems the unfinished analyses of other aspects of the site (i.e., faunal and botanical remains) and the absence of comparative Middle Archaic skeletal material from Middle Tennessee limit the conclusions that can be made regarding the demographic structure and the health and nutritional status of the Anderson people. Despite these problems, this study provides comparative data for other skeletal studies in the Southeast as well as the first biological data to complement on-going archaeological research of human ecology during the Middle Archaic period in Middle Tennessee.

Based on the assumption that the Anderson series represents a reasonable approximation of the individuals who died at the site, the vital statistics of the population were reconstructed using a life table approach. Subadult mortality rates were highest during infancy and probably reflect various problems associated with pregnancy and childbirth. After the first year of life mortality rates declined, remained relatively low well into middle age, and then rapidly rose again in old age. Survivorship data indicated that approximately one-half of the population survived to the age of 20 and another one-fourth to the age of 40. The age-specific mortality data suggested that individuals most subject to disease and death were infants and older adults (35+ years); those least subject to disease and death were children and young adults. Life expectancy at birth was 23 years and the crude mortality rate was 43 individuals per 1000 per annum, values which agree with comparative skeletal populations assumed to represent "average" aboriginal conditions.

Further insight into the health and nutritional status of the Anderson population was gained in an investigation of long bone growth patterns. Studies on living populations have demonstrated that growth retardation in young children is related to nutritional deficiencies and infectious diseases. In studies of skeletal remains, long bone growth has been used as a measure of nutritional and disease stress in temporally sequential populations from the same geographical regions but characterized by a shift in subsistence patterns or in different external stresses (e.g., precontact vs. postcontact conditions). In the present study similar rates of long bone growth occurred between the Anderson children and a sample of Arikara children from about 0.5 to 11.9 years. These results agreed with the expectation that a diverse diet would have provided adequate nutrient requirements necessary for growth and maintenance in the Anderson children and that their growth rates would not differ from those of other Indian populations characterized by an "adequate" or "good" nutritional status. An examination of adult mean femur lengths indicated that, in general, the growth rates established during childhood were maintained through adolescence and into adulthood. No difference in mean femur length was detected between Anderson males and other males in the Indian Knoll population or in populations from other geographical areas and/or other subsistence patterns. The Anderson females exhibited a similar pattern except their mean femur length was significantly smaller than that of females from Late Mississippian populations in Tennessee. A closer examination of the mean femur lengths of adults from Southeast-Archaic and Southeast-Mississippian populations suggested than an increase in size occurred from Archaic to Mississippian times but that females were more affected by this increase than males. These results contradict the findings of current research which has demonstrated that a decrease in size occurred with a shift to maize agriculture. It was suggested that the present results might reflect a more rigorous lifeway amoung the hunter-gatherer populations wherein the functional demands made on the female body limited them from attaining their inherited growth potential or that the results might reflect other factors such as selection favoring small body size in populations with relatively predictable food resource availability. Although it was impossible to determine the actual cause of this situation, resource availability was probably an important factor in the early establishment of growth and maintenance in Anderson children. Indeed, this period of growth coincided with the subadult age intervals with the lowest probabilities of morbidity and death.

Pathology data also indicated relatively healthy conditions for the Anderson population. Subadults were generally free from pathologies. The only notable condition was the greater incidence of fractures during adolescence which possibly reflected stresses associated with the assumption of adult roles (e.g., hunting), and other factors associated with a hunting-gathering lifeway.

Most of the pathology conditions were found in adults. The most common problems were those associated with degenerative arthritis, dental diseases and fractures, respectively. Twenty-nine adults were affected by degenerative arthritis, the incidence of which increased with age. The elbow was the most frequently involved joint followed by the knee, the cervical/lumbar combination, the hip, shoulder and finally the thoracic joints. Males tended to be more frequently affected by degenerative arthritis than females, a situation which perhaps reflects the differences in male-female subsistence activities in a hunter-gatherer society.

Dental abscesses and antemortum tooth loss were also more frequent with increasing age and more common in males than females. Associated with marked dental wear and relatively few carious lesions, these pathologies were attributed to an abrasive diet.

Fractures were more common in males than in females and more common in adults than in subadults. Most fractures were adequately healed and all showed good alignment.

All of the above data--vital statistics, long bone growth, and pathology patterns--indicate that the Anderson skeletal sample might represent a relatively healthy, well-adapted population. This must be considered as a tentative conclusion, however, until the analyses of other sources of evidence are completed for the Anderson site and for other Archaic sites in Middle Tennessee. Expansion of the present data to include other large Archaic skeletal series, like Indian Knoll or Eva and Cherry, is also necessary before any reliable conclusions can be made about the adaptive success of Archaic populations in the Southeast.

The types of data evaluated in this study provide only some of the perspectives that can be taken in an analysis of skeletal remains. Further investigation of the health status of the Anderson and of other Archaic populations might include other skeletal stress markers like Harris lines, dental hypoplasias, fluctuating dental asymmetry or cortical bone remodeling. These studies would contribute additional data to fit into the framework provided by this thesis.

REFERENCES CITED

REFERENCES CITED

Acsadi, G. Y. and T. Nemeskeri
1970 History of Human Life Span and Mortality. Budapest: Akademiai Kiado.

Angel, J. L.
1969 The Bases of Paleodemography. American Journal of Physical Anthropology 30:427-438.

1971 The People of Lerna. Analysis of a Prehistoric Aegian Population. Washington, D.C. and Princeton: American School of Classical Studies at Athens and Smithsonian Institution Press.

1975 Paleoecology, Paleodemography, and Health. In Population Ecology and Social Evolution. S. Polgar, ed. Chicago: Aldine Publishers.

Armelagos, G. J. and J. R. Dewey
1970 Evolutionary Response to Human Infectious Diseases. Bioscience 157:638-644.

Asch, N. B., R. I. Ford, and D. L. Asch
1972 Paleoethnobotany of the Koster Site. Illinois State Museum. Reports of Investigations No. 24, Springfield.

Aschcroft, M. T., P. Heneage, and H. G. Lovell
1966 Heights and Weights of Jamaican Schoolchildren of Various Ethnic Groups. American Journal of Physical Anthropology 24:35-44.

Baetjer, F. H. and C. A. Waters
1921 Injuries and Diseases of the Bones and Joints. New York: Paul B. Hoeber.

Bass, W. M.
1971 Human Osteology: A Laboratory and Field Manual of the Human Skeleton. Columbia: Missouri Archaeological Society.

Bennett, K. A.
1973a On the Estimation of Some Demographic Characteristics on a Prehistoric Population From the American Southwest. American Journal of Physical Anthropology 39:223-232.

1973b The Indians of Point of Pines, Arizona: A Comparative Study of Their Physical Characteristics. Tuscon: The University of Arizona Press, Anthropology Papers No. 23.

Berryman, H. E.
1981 The Averbuch Skeletal Series: A Study of Biological Social Stress at a Late Mississippian Period Site From Middle Tennessee. Doctoral dissertation. Department of Anthropology, University of Tennessee, Knoxville.

Birbeck, J. A. and M. Lee
1973 Growth and Skeletal Maturation in British Columbia Indian Populations. American Journal of Physical Anthropology 38: 727-738.

Black, T. K., III.
1978 A New Method for Assessing the Sex of Fragmentary Skeletal Remains: Femoral Shaft Circumference. American Journal of Physical Anthropology 48:227-232.

Blakely, R.
1971 Comparison of the Mortality Profiles of the Archaic, Middle Woodland, and Middle Mississippian Skeletal Populations. American Journal of Physical Anthropology 34:43-54.

Bowen, W. R.
1975 Late Archaic Subsistence and Settlement in the Western Tennessee Valley: A Reevaluation. Master's thesis. Department of Anthropology, University of Tennessee, Knoxville.

Boyce, M. S.
1979 Seasonality and Patterns of Natural Selection for Life Histories. The American Naturalist 114:569-583.

Braun, E. L.
1950 Deciduous Forests of Eastern North America. Philadelphia: Blakiston Company.

1955 The Physiography of Unglaciated Eastern United States and Its Interpretation. Botanical Review 21:297-375.

Brothwell, D. R., ed.
1968 The Skeletal Biology of Earlier Human Populations. New York: Pergamon Press.

Brothwell, D. R.,and A. T. Sandison, eds.
1967 Diseases in Antiquity. Springfield: Charles C. Thomas.

Buikstra, J. E.
1975 Mortuary Activity and Human Ecology: Preliminary Observations. In The Koster Site: A Progress Report. J. A. Brown, ed. Northwestern University Archaeological Program Special Report No. 1, Evanston.

Buikstra, J. E. and D. C. Cook
1980 Paleopathology: An American Account. Annual Review of Anthropology 9:433-470.

Cambron, J. W. and D. C. Hulse
1975 Handbook of Alabama Archaeology, Part I: Point Types. Birmingham: Archaeological Research Association of Alabama, Inc.

Carrier, N.
1958 A Note on the Estimation of Mortality and Other Population Characteristics Given Deaths By Age. Population Studies 12: 149-163.

Chapman, J.
1975 The Rose Island Site and the Bifurcate Point Tradition. Report of Investigations No. 14, Department of Anthropology, University of Tennessee, Knoxville.

1976 The Archaic Period in the Lower Little Tennessee River Valley: Radiocarbon Dates. Tennessee Anthropologist 1:1-12.

1977 Archaic Period Research in the Lower Little Tennessee River Valley--1975; Icehouse Bottom, Harrison Branch, Thirty Acre Island, Calloway Island. Report of Investigations No. 18, Department of Anthropology, University of Tennessee, Knoxville.

1979 Archaeological Investigations at the Howard (40MR66) and Calloway Island (40MR41) Sites. Report of Investigations No. 27, Department of Anthropology, University of Tennessee, Knoxville.

Cole, P. E.
1975 Archaic Populations of the Middle South: A Multivariate Analysis. Tennessee Archaeologist 31:87-97.

Cook, D. C.
1972 Subsistence Base and Growth Rate in Four Illinois Woodland Populations. American Journal of Physical Anthropology 37:433.

1976 Pathological States and Disease Process in Illinois Woodland Populations: An Epidemiological Approach. Doctoral dissertation, University of Chicago.

1979 Subsistence Base and Health in Prehistoric Illinois Valley: Evidence From the Human Skeleton. Medical Anthropology 3: 109-123.

Crane, H. R.
1956 University of Michigan Radiocarbon Dates I. Science 124: 664-671.

Crites, G. D.
1982 Carbonized Ligeneous Material From Cheek Bend Cave: Paleoenvironment in the Nashville Basin. In Paleontology of Cheek Bend Cave: Phase II Report, W. E. Klippel and P. W. Parmalee. Tennessee Valley Authority Investigations, Draft Copy.

Dejarnette, D. L. , E. B. Kurjack, and J. W. Cambron
1962 Stanfield-Worley Bluff Shelter Excavations. Journal of Alabama Archaeology 8(Parts I and II).

Dejarnette, D. L., J. Walthall, and S. Wimberly
1975 Archaeological Investigations in the Buttahatchee River Valley II: Excavations at Stucks Bluff Rockshelter. Journal of Alabama Archaeology 21:99-119.

Delcourt, H. R.
1979 Late Quaternary Vegetation History of the Eastern Highland Rim and Adjacent Cumberland Plateau of Tennessee. Ecological Monographs 49:255-280.

Delcourt, P. A. and H. R. Delcourt
1979 Late Pleistocene and Holocene Distributional History of the Deciduous Forest in the Eastern United States. Veröffentlichungen des Geobotanischen Institutes der ETH, Stiftung Rübel (Zurich) Heft 68:79-107.

Dickson, R. H.
1974 The Climate of Tennessee. In Climates of the States. Volume I--Eastern States Plus Puerto Rico and the U. S. Virgin Islands. By the Officials of the National Oceanic and Atmospheric Administration, U. S. Department of Commerce. New York: Water Information Center, Inc.

Dowd, J. T.
1981 The Anderson Site (40WM9). Tennessee Anthropological Association Newsletter 6:1-2.

Dunn, F. L.
1968 Epidemiological Factors: Health and Disease in Hunter-Gatherers. In Man the Hunter. R. B. Lee and I. DeVore, eds. New York: Aldine Publishing Company.

Dwight, T.
1905 The Size of the Articular Surfaces of the Long Bones as Characteristics of Sex: An Anthropological Study. American Journal of Anatomy 4:19-31.

Edwards, M. J., J. A. Elder, and M. E. Springer
1974 The Soils of the Nashville Basin. U.S. Department of Agriculture, Soil Conservation Service, Bulletin 499.

Eveleth, P. B. and J. M. Tanner
1976 Worldwide Variation in Human Growth. New York: Cambridge University Press.

Fabrega, Jr., H.
1981 Culture, Biology and the Study of Disease. In Biocultural Aspects of Disease. H. Rothschild, ed. New York: Academic Press.

Faulkner, C. H.
1977 Eoff III Site (40Cf107). In Fourth Report of the Normandy Archaeological Project. C. H. Faulkner and M. C. R. McCollough, eds. Report of Investigations No. 19, Department of Anthropology, University of Tennessee, Knoxville.

Faulkner, C. H. and M. C. R. McCollough
1973 Introductory Report of the Normandy Reservoir Salvage Project: Environmental Setting, Typology, and Survey. Report of Investigations No. 11, Department of Anthropology, University of Tennessee, Knoxville.

Fenneman, N. M.
1938 Physiography of the Eastern United States. New York: McGraw-Hill Book Company, Inc.

Fenner, R.
1980 Sociocultural Change and Environmental Disease. In Changing Disease Patterns and Human Behavior. N. F. Stanley and R. A. Joske, eds. New York: Academic Press.

Frayer, D. W.
1980 Sexual Dimorphism and Cultural Evolution in the Late Pleistocene and Holocene of Europe. Journal of Human Evolution 9:399-415.

Frisancho, A. R.
1980 Role of Calorie and Protein Reserves on Human Growth During Childhood and Adolescence in a Mestizo Peruvian Population. In Social and Biological Predictors of Nutritional Status, Physical Growth, and Neurological Development. L. S. Green and F. E. Johnston, eds. New York: Academic Press.

Frisancho, A. R., S. M. Garn, and W. Ascoli
1970a Population Differences in Skeletal Maturation and its Relationship to Growth in Body Size. American Journal of Physical Anthropology 33:130.

1970b Childhood Retardation Resulting in Reduction of Adult Body Size Due to Lesser Adolescent Skeletal Delay. American Journal of Physical Anthropology 33:325-336.

Garn, S. M., A. B. Lewis and D. L. Polacheck
1959 Variability of Tooth Formation. Journal of Dental Research 38:135-148.

Garn, S. M., F. N. Silverman, K. P. Hertzog, and C. G. Rohmann
1968 Lines and Bands of Increased Density. Medical Radiography and Photography 44:58-80.

Genoves, S. C.
1967 Proportionality of Long Bones and Their Relation to Stature Among Mesoamericans. American Journal of Physical Anthropology 26:67-78.

Gilbert, B. M.
1973 Misapplication to Females of the Standard for Aging the Male Os pubis. American Journal of Physical Anthropology 38:39-40.

Gilbert, B. M. and T. McKern
1973 A Method for Aging the Female Os pubis. American Journal of Physical Anthropology 38:31-38.

Goldstein, M. S.
1963 The Paleopathology of Human Skeletal Remains. In Science in Archaeology. D. Brothwell and E. Higgs, eds. London: Thames and Hudson.

Griffin, J. B.
1967 Eastern North American Archaeology: A Summary. Science 156:175-191.

Gualiardo, M. F.
1980 Fluctuating Dental Asymmetry and Stress at the Averbuch Site (40DV60). Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.

1982 Tooth Crown Size Differences Between Age Groups: A Possible Indicator of Stress in Skeletal Samples. American Journal of Physical Anthropology 58:383-389.

Hofman, J. L.
n.d. Toward a Model of Human Ecology in the Central Duck River Basin During Middle Archaic Times (7500-4000 B.P.). Manuscript on file, Department of Anthropology, University of Tennessee, Knoxville.

1982 Radiocarbon Dates From the Eva-Morrow Mountain Component at the Cave Spring Site, 40MU141, Middle Tennessee. Tennessee Anthropological Association Newsletter 7:1-3.

Hooton, E. A.
1930 Indians of Pecos Pueblo. New Haven, Conn.: Yale University Press.

Houghton, P.
1974 The Relationship of the Pre-auricular Groove of the Ilium to Pregnancy. American Journal of Physical Anthropology 41:381-389.

Howell, N.
1973 The Feasibility of Demographic Studies in "Anthropological" Populations. In Methods and Theories of Anthropological Genetics. M. H. Crawford and P. L. Workman, eds. Albuquerque: University of New Mexico Press.

1976 Toward a Uniformitarian Theory of Human Paleodemography. In The Demographic Evolution of Human Populations. R. H. Ward and K. M. Weiss, eds. New York: Academic Press.

Howells, W. W.
1960 Estimating Population Numbers Through Archaeological and Skeletal Remains. In The Application of Quantitative Methods in Archaeology. R. Heizer and S. Cook, eds. Viking Fund Publications in Anthropology No. 28. Chicago: Quadrangle Books.

Hunt, Jr., E. E. and I. Gleiser
1955 The Estimation of Age and Sex of Preadolescent Children From Bones and Teeth. American Journal of Physical Anthropology 13:479-487.

Jaffe, H. L.
1972 Metabolic, Degenerative, and Inflammatory Diseases of Bones and Joints. Philadelphia: Lea and Febiger.

Jantz, R. L. and D. W. Owsley
n.d. Long Bone Growth Variation Among Arikara Skeletal Populations. Manuscript in preparation, Department of Anthropology, University of Tennessee, Knoxville.

Jenkins, C. L.
1981 Patterns of Growth and Malnutrition Among Preschoolers in Belize. American Journal of Physical Anthropology 56:169-178.

Johnston, F. E.
1962 Growth of the Long Bones of Infants and Young Children at Indian Knoll. American Journal of Physical Anthropology 20:249-254.

1968 Growth in the Skeleton in Early Peoples. In The Skeletal Biology of Early Human Populations. D. R. Brothwell, ed. New York: Pergamon Press.

1980 Research and Design Sample Selection. In Human Physical Growth and Maturation. F. E. Johnston, A. F. Roche and C. Susanne, eds. New York: Plenum Press.

Johnston, R. E., B. Newman, J. Cravioto, E. Delicardie, and T. Scholl
1980 A Factor Analysis of Correlates of Nutritional Status in Mexican Children, Birth to 3 Years. In Social and Biological Predictors of Nutritional Stress, Physical Growth, and Neurological Development. L. S. Greene and F. E. Johnston, eds. New York: Academic Press.

Johnston, F. E. and C. E. Snow
1961 The Reassessment of the Age and Sex of the Indian Knoll Skeletal Population: Demographic and Methodological Aspects. American Journal of Physical Anthropology 19:237-244.

Johnston, F. E., H. Wainer, D. Thissen, and R. MacVean
1976 Hereditary and Environmental Determinants of Growth in Height in a Longitudinal Sample of Children and Youth of Guatemalan and European Ancestry. American Journal of Physical Anthropology 44:469-475.

Jurmain, R. D.
1977 Stress and Etiology of Osteoarthritis. American Journal of Physical Anthropology 46:353-366.

1980 The Pattern of Involvement of Appendicular Degenerative Joint Disease. American Journal of Physical Anthropology 53: 143-150.

Keen, J. A.
1950 A Study of the Differences Between Male and Female Skulls. American Journal of Physical Anthropology 8:65-79.

Keller, E. E., A. H. Sather, and A. B. Hoyles
1970 Dental and Skeletal Development in Various Endocrine and Metabolic Diseases. Journal of the American Dental Association 81:415-419.

Kerley, E. R.
1965 The Microscopic Determination of Age in Human Bone. American Journal of Physical Anthropology 23:149-163.

Klippel, W. E. and P. W. Parmalee
1982 The Paleontology of Cheek Bend Cave: Phase II Report. The Tennessee Valley Authority, Knoxville. Draft Copy.

Kolata, G. B.
1974 !Kung Hunter-Gatherers: Feminism, Diet and Birth Control. Science 185:932-934.

Krogman, W. M.
1962 The Human Skeleton in Forensic Medicine. Springfield: Charles C. Thomas.

Lange, F. W.
1980 Prehistory and Hunter/Gatherers: The Role of Analogs. Midcontinental Journal of Archaeology 5:133-147.

Larsen, C. S.
1982 The Anthropology of St. Catherine's Island 3. Prehistoric Human Biological Adaptation. Anthropological Papers of the American Museum of Natural History, Vol. 57, Part 3, New York.

Lewis, A. B. and S. M. Garn
1960 The Relationship Between Tooth Formation and Other Maturational Factors. Angle Orthodontics 30:70-77.

Lewis, T. M. N. and M. Kneberg
1947 The Archaic Horizon in Western Tennessee. Tennessee Anthropology Papers No. 2, University of Tennessee, Knoxville.

1959 The Archaic Culture in the Middle South. American Antiquity 25:161-183.

Lewis, T. M. N. and M. K. Lewis
1961 Eva: An Archaic Site. A University of Tennessee Study in Anthropology. Knoxville: The University of Tennessee Press.

Lotka, A.
1907 Relation Between Birth Rates and Death Rates. Science 26:21-22.

Lovejoy, C. O.
1971 Methods For the Detection of Census Error in Paleodemography. American Anthropologist 73:101-109.

Lovejoy, C. O., R. Meindl, T. Pryzbeck, T. Barton, K. Heiple, and D. Knotting
1977 Paleodemography of the Libben Site, Ottawa County, Ohio. Science 198:291-293.

Loveland, C. J.
1980 The Skeletal Biology of the Caddo Indians of the Kaufman-Williams Site, Red River County, Texas. Doctoral dissertation, Department of Anthropology, University of Tennessee, Knoxville.

Magennis, A. L.
1977 Middle and Late Archaic Mortuary Patterning: An Example From the Western Tennessee Valley. Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.

Marshall, W. A.
1968 Problems in Relating the Presence of Transverse Lines in the Radius to the Occurrence of Disease. In The Skeletal Biology of Earlier Human Populations. D. R. Brothwell, ed. New York: Pergamon Press.

Martorell, R.
1980 Interrelationships Between Diet, Infectious Disease, and Nutritional Status. In Social and Biological Predictors of Nutritional Status, Physical Growth, and Neurological Development. L. S. Green and F. E. Johnston, eds. New York: Academic Press.

Martorell, R., C. Yarbrough, A. Lechtig, J. P. Habicht, and R. E. Klein
1975 Diarrheal Diseases and Growth Retardation in Preschool Guatemalan Children. American Journal of Physical Anthropology 43:341-346.

McCall, R. and I. Schour
1960 Chronology of the Human Dentition. In Oral Pathology. K. Thomas and H. Goldman, eds. St. Louis: C. V. Mosley and Company.

McKay, R. H.
1961 Skeletal Maturation. Chart. Rochester, N. Y.: Eastman Kodak Company.

McKern, T. W. and T. D. Stewart
1957 Skeletal Age Changes in Young American Males, Analyzed From the Standpoint of Identification. Natick, Mass.: Headquarters Quartermaster Research and Development Command, Technical Report EP-45.

McMahan, D.
n.d. Human Skeletal Remains From the Garrett Site, 40BD1. Manuscript on file. Department of Anthropology, University of Tennessee, Knoxville.

Mensforth, R. P., C. O. Lovejoy, J. W. Lallo and G. J. Armelagos
1978 The Role of Constitutional Factors, Diet, and Infectious Disease in the Etiology of Porotic Hyperostosis and Periosteal Reactions in Prehistoric Infants and Children. Medical Anthropology 2:1-59.

Merchant, V. L. and D. H. Ubelaker
1977 Skeletal Growth of the Protohistoric Arikara. American Journal of Physical Anthropology 46:61-72.

Moorrees, C. F. A., E. A. Fanning, and E. E. Hunt, Jr.
1963a Formation and Resorption of Three Deciduous Teeth in Children. American Journal of Physical Anthropology 21:205-213.

1963b Age Variation of Formation Stages For Ten Permanent Teeth. Journal of Dental Research 42:1490-1502.

Moran, E. F.
1979 Human Adaptability: An Introduction to Ecological Anthropology. North Scituate, Mass.: Duxbury Press.

Morse, D.
1969 Ancient Disease in the Midwest. Reports of Investigations No. 15, Illinois State Museum, Springfield.

Muller, J. D.
1978 The Southeast. In Ancient Native Americans. J. D. Jennings, ed. San Francisco: W. H. Freeman and Company.

Neter, J. and W. Wasserman
1974 Applied Linear Statistical Models: Regression, Analysis of Variance, and Experimental Designs. Homewood, Ill.: Richard D. Irwin, Inc.

Neumann, H. W.
1967 The Paleopathology of the Archaic Modoc Rock Shelter Inhabitants. Reports of Investigations No. 11, Illinois State Museum, Springfield.

Newman, M. T.
1975 Nutritional Adaptation in Man. In Physiological Anthropology. A. Damon, ed. New York: Oxford University Press.

Nickens, P. R.
1976 Stature Reduction as an Adaptive Response to Food Production in Mesoamerica. Journal of Archaeological Science 3:31-41.

Ortner, D. J.
1968 Description and Classification of Degenerative Bone Changes in the Distal Joint Surface of the Humerus. American Journal of Physical Anthropology 28:139-156.

Ortner, D. J. and W. G. J. Putschar
1981 Identification of Pathological Conditions in Human Skeletal

Remains. Smithsonian Contributions to Anthropology No. 28. Washington, D.C.: Smithsonian Institution Press.

Owsley, D. W.
1975 A Demographic Analysis of Skeletons From the Larson Site (39WW2) Walworth County, South Dakota. Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.

Owsley, D. W. and W. M. Bass
1979 A Demographic Analysis of Skeletons From the Larson Site: (39WW2) Walworth County, South Dakota: Vital Statistics. American Journal of Physical Anthropology 51:145-154.

Owsley, D. W. and R. L. Jantz
n.d. Formation of the Permanent Dentition in Arikara Indians: Timing Differences That Affect Dental Age Assessments. Manuscript in preparation. Department of Geography and Anthropology, Louisiana State University, Baton Rouge.

Palkovich, A. M.
1978 A Model of the Dimensions of Mortality and Its Application to Paleodemography. Doctoral dissertation. Northwestern University, Evanston.

Parham, K. R.
1982 A Biocultural Approach to the Skeletal Biology of the Dallas People From Toqua. Master's thesis, Department of Anthropology, University of Tennessee, Knoxville.

Parmalee, P. W. and W. E. Klippel
1974 Freshwater Mussels as a Prehistoric Food Resource. American Antiquity 39:421-434.

Pearson, K. and J. Bell
1919 A Study of Long Bones of the English Skeleton I: The Femur. Department of Applied Statistics, University of London, University College, Drapers' Company Research Memoirs, Biometric Series X, Chapters 1-6.

Phenice, T. W.
1969 A Newly Developed Visual Method of Sexing the Os pubis. American Journal of Physical Anthropology 30:297-302.

Polgar, S.
1964 Evolution and the Ills of Mankind. In Horizons of Anthropology. S. Tax, ed. New York: Prentice-Hall Publishers.

Putschar, W. G. J.
1976 The Structure of the Human Symphysis With Special Consideration of Parturition and Its Sequelae. American Journal of Physical Anthropology 45:589-594.

Sandison, A. T.
1968 Pathological Changes in the Skeletons of Earlier Populations Due to Acquired Disease, and Difficulties in their Interpretation. In The Skeletal Biology of Earlier Human Populations. D. R. Brothwell, ed. New York: Pergamon Press.

SAS Institute
1982 User's Guide, 1982 edition. Cary, N.C.: SAS Institute.

Scholl, T. O., F. E. Johnston, J. Cravioto, E. R. DeLicardio, and D. S. Lurie
1979 The Relationship of Growth Failure (Chronic Undernutrition) to the Prevalence of Clinically Severe Protein-Energy Malnutrition and to Growth Retardation in Protein-Energy Malnutrition. American Journal of Clinical Nutrition 32:872-878.

Schour, I. and M. Massler
1941 The Development of the Human Dentition. Journal of the American Dental Association 28:1153-1160.

1944 The Development of the Human Dentition. Chart.

Sensing, E. C. and J. E. Hoar
1962 Skeletal Material From the Stanfield-Worley Bluff Shelter. Journal of Alabama Archaeology 8:519-523.

Service, E. R.
1975 Origins of the State and Civilization: The Process of Cultural Evolution. New York: W. W. Norton.

Sinclair, D.
1968 Human Growth After Birth. New York: Oxford University Press.

Singer, R.
1953 Estimation of Age From Cranial Suture Closure. Journal For Medicine 1:52-59.

Snow, C. E.
1948 Indian Knoll Skeletons of Site Oh2, Ohio County, Kentucky. Reports in Anthropology Vol. IV, No. 3, Part II, University of Kentucky, Lexington.

Steinbock, R. T.
1976 Pathological Diagnosis and Interpretation: Bone Diseases in Ancient Human Populations. Springfield: Charles C. Thomas.

Stewart, T. D.
1958 The Rate of Development of Vertebral Osteoarthritis in American Whites and Its Significance in Skeletal Age Identification. The Leech 28:144-151.

1962 Comments on the Reassessment of the Indian Knoll Skeletons. American Journal of Physical Anthropology 20:143-148.

1970 Identification of the Scars of Parturition in the Skeletal Remains of Females. In Personal Identification in Mass Disasters. T. D. Stewart, ed. Washington, D.C.: Smithsonian Institution Press.

1979 Essentials of Forensic Anthropology. Springfield: Charles C. Thomas.

Strand, R. H., H. A. Frebourg, and J. V. Vaiksnoras
1973 Precipitation Probabilities for Middle Tennessee. Universite of Tennessee Agricultural Experiment Station, Bulletin 511.

Suchey, J. M., D. V. Wiseley, R. F. Green, and T. T. Nogushi
1979 Analysis of Dorsal Pitting in the Os pubis in an Extensive Sample of Modern American Females. American Journal of Physical Anthropology 51:517-540.

Sundick, R. I.
1978 Human Skeletal Growth and Age Determination. Homo 29: 228-249.

Swedlund, A. C. and W. D. Wade
1972 Laboratory Methods in Physical Anthropology. Prescott, Ariz.: Prescott College Press.

Tatsuoka, M. M.
1971 Multivariate Analysis: Techniques For Educational and Psychological Research. New York: John Wiley and Sons, Inc.

Todd, T. W.
1920 Age Changes in the Pubic Bone, Part I. American Journal of Physical Anthropology 3:285-334.

1921 Age Changes in the Pubic Bone, Parts II-IV. American Journal of Physical Anthropology 4:1-70.

Todd, T. W. and D. W. Lyon
1924 Endocranial Suture Closure, Its Progress and Age Relationship, Part I: Adult Males of White Stock. American Journal of Physical Anthropology 7:325-384.

1925 Cranial Suture Closure, Its Progress and Age Relationship, Part II: Ectocranial Suture Closure in Adult Males of White Stock. American Journal of Physical Anthropology 8:23-71.

Trotter, M. and G. C. Gleser
1958 A Re-evaluation of Estimation of Stature Based on Measurements of Stature Taken During Life and of Long Bones After

Death. American Journal of Physical Anthropology 16: 79-123.

True, J. C., J. F. Campbell, E. P. Davis, O. G. Sprouse, Jr., J. F. Brasfield, and I. D. Howell
1961 Soil Survey of Williamson County, Tennessee. U. S. Department of Agriculture, Soil Conservation Service, Report No. 5. Washington, D.C.: U. S. Government Printing Office.

Truswell, A. S. and J. D. L. Hansen
1976 Medical Research Among the !Kung. In Kalahari Hunter-Gatherers. R. B. Lee and I. DeVore, eds. Cambridge, Mass.: Harvard University Press.

Turnbull, C. M.
1965 Wayward Servants: The Two Worlds of the African Pygmies. Garden City, N.Y.: Natural History Press.

Turner, C. G.
1979 Dental Anthropological Indicators of Agriculture Among the Jomon People of Central Japan. American Journal of Physical Anthropology 51:619-636.

Ubelaker, D. H.
1974 Reconstruction of Demographic Profiles From Ossuary Samples: A Case Study From the Tidewater Potomac. Smithsonian Contributions to Anthropology No. 18. Washington, D.C.: Smithsonian Institution Press.

1978 Human Skeletal Remains. Washington, D.C.: Taraxacum.

United Nations
1955 Age and Sex Patterns of Mortality. Model Life Tables For Under-Developed Countries. Population Studies No. 22, Department of Social Affairs, Population Branch, New York.

United States Department of Interior Geological Survey
1949 Leipers Fork Quadrangle, 63NW. Knoxville: U. S. Tennessee Valley Authority.

Vallois, H. V.
1960 Vital Statistics in Prehistoric Populations as Determined From Archaeological Data. In The Application of Quantitative Methods in Archaeology. R. Heizer and S. Cook, eds. Viking Fund Publications in Anthropology No. 28. Chicago: Quadrangle Books.

Walker, P. L.
1969 The Linear Growth of Long Bones in Late Woodland Indian Children. Proceedings of the Indiana Academy of Science 78: 83-87.

Ward, Jr., J. W.
1972 A Comparative Study of the Arnold and Ganier Populations Based on Osteological Observations. In The Middle Cumberland Culture. R. B. Ferguson, ed. Vanderbilt University Publications in Anthropology No. 3, Nashville.

Webb, W. S.
1945 Indian Knoll Site OH2. Reports in Anthropology Vol. IV, No. 3, Part I, University of Kentucky, Lexington.

Weiss, K. M.
1973 Demographic Models For Anthropology. Society for American Archaeology Memoir 27.

Weiss, K. M. and P. E. Smouse
1976 The Demographic Stability of Small Human Populations. In The Demographic Evolution of Human Populations. R. H. Ward and K. M. Weiss, eds. New York: Academic Press.

Wells, C.
1964 Bones, Bodies, and Disease. New York: Frederick A. Praeger.

Willey, P. S.
1982 Osteology of the Crow Creek Massacre. Doctoral dissertation, Department of Anthropology, University of Tennessee, Knoxville.

Wing, E. S. and A. B. Brown
1979 Paleonutrition: Method and Theory in Prehistoric Foodways. New York: Academic Press.

Wobst, H. M.
1978 The Archaeo-Ethnology of Hunter-Gatherers or the Tyranny of the Ethnographic Record in Archaeology. American Antiquity 43:303-309.

Wright, Jr., H. E.
1976 The Dynamic Nature of Holocene Vegetation. A Problem in Paleoclimatology, Biogeography, and Stratigraphic Nomenclature. Quaternary Research 6:581-596.

Y'edynak, G.
1976 Long Bone Growth in Western Eskimo and Aleut Skeletons. American Journal of Physical Anthropology 45:569-574.

Yellen, J. and H. Harpending
1972 Hunter-Gatherer Archaeological Inferences. World Archaeology 4:244-253.

Yudkin, J.
1969 Archaeology and the Nutritionist. In The Domestication and Exploitation of Plants and Animals. P. J. Ucko and G. W. Dimbleby, eds. Chicago: Aldine Press.

APPENDICES

APPENDIX A

AGE AND SEX DISTRIBUTION OF THE ANDERSON SKELETAL SERIES

Table 18. Age and Sex Distribution of the Anderson Skeletal Series*

Burial Number	Burial Goods	Stratum	Age	Sex
1	X	2	21	F
2		1	30-34	?
3		5	50+	F
4	X	1	50+	F
5		3	1.35	?
6		3	10.035	?
7		4	0.6275	?
8		2	40-49	(F)
9		3	15-19	(M)
10a		6	20	F
11	X	1	15	?
12	X	1	18	(F)
13	X	3	40-49	M
14		4	19	F
15	X	4	0.5450	?
16		3	6.2567	?
17	X	5	2.2500	?
18	X	6	19	M
19		1	30-34	F
20	X	2	50+	F
21		2	7.025	?
22	X	1	0-1	?
23	X	4	50+	M
24		4	40-49	M
25		3	40-49	F
26	X	3	11-13	?
27		4	10.535	?
28		3	50+	F
29	X	4	30-34	F
30	X	1	30+	M
31	X	3	20+	?
32		5	18.5	F
33		5	11.89	?
34		1	40-49	?
35		2	40-49	M
36	X	2	0.490	?
37	X	2	30+	F
38		2	40-49	F
39		2	35-39	M
40		2	0.720	?
41		3	30-39	?
42	X	2	9.75	?

Table 18 (continued)

Burial Number	Burial Goods	Stratum	Age	Sex
43	X	3	25-29	M
44		3	0.470	?
45		3	40-49	F
46		3	0-0.5	?
47	X	1	10.01	?
48		2	0-1.0	?
49		2	33	F
50		3	47.75	F
51		6	0.510	?
52		4	20.84	M
53	X	4	20+	?
54	X	3	47.75	F
55		5	35-39	M
56	X	5	10.535	?
57		5	1.140	?
58	X	6	11-13	?
59	X	6	21	F
60		1	0.5-1.0	?
61		7	0.545	?
62		2	35+	F
63		2	50+	M
64		2	30-34	(F)
65	X	3	0-1.0	?
66	X	3	40-49	M
67		3	1.140	?
68		3	0-1.0	?
69		3	30+	F
70		4	35-39	F
71		4	40-49	M
72		4	0-0.5	?
73	X	3	20+	?

*Parentheses denote probable sex.

APPENDIX B

LONG BONE GROWTH CODING FORMAT

LONG BONE GROWTH CODING FORMAT

Column	Code	Description
1-3	1	Site: 40WM9
5-6	Blank	Feature
7-11		Burial Number
13		Sex:
	1	Male
	2	Female
	3	Subadult, sex unknown
	4	Adult, sex unknown
15-16	Blank	Age
17		Teeth:
	1	Present
	2	Absent
18-43		Tooth Ratings:
18-19	See Attached	c (mandibular)
20-21		m_1
22-23		m_2
24-25		I^1
26-27		I^2
28-29		I_1
30-31		I_2
32-33		C (mandibular)
34-35		P_1
36-37		P_2
38-39		M_1
40-41		M_2
42-43		M_3

Column	Code	Description
44-79		Long Bone Lengths (in millimeters):
44-46		Left Humerus
47-49		Right Humerus
50-52		Left Radius
53-55		Right Radius
56-58		Left Ulna
59-61		Right Ulna
62-64		Left Femur
65-67		Right Femur
68-70		Left Tibia
71-73		Right Tibia
74-76		Left Fibula
77-79		Right Fibula

Tooth Ratings:

c, m_1, m_2:

1. Cco
2. Coc
3. Cr½
4. Cr 3/4
5. CrC
6. Ri
7. Cli
8. R¼
9. R½
10. R 3/4
11. Rc
12. A½
13. Ac

M_1, M_2, M_3:

1. Ci
2. Cco
3. Coc
4. Cr½
5. Cr 3/4
6. CrC
7. Ri
8. Cli
9. R¼
10. R½
11. R 3/4
12. Rc
13. A½
14. Ac

Tooth Ratings (continued):

C, P_1, P_2:

1. Ci
2. Cco
3. Coc
4. Cr½
5. Cr 3/4
6. CrC
7. Ri
8. R¼
9. R½
10. R 3/4
11. Rc
12. A½
13. Ac

I^1, I^2:

7. CrC
8. Ri
9. R¼
10. R 1/3
11. R½
12. R 2/3
13. R 3/4
14. Rc
15. A½
16. Ac

I_1, I_2:

9. R¼
10. R 1/3
11. R½
12. R 2/3
13. R 3/4
14. Rc
15. A½
16. Ac

APPENDIX C

PATHOLOGY CODING FORMAT

PATHOLOGY CODING FORMAT

Column	Code	Description
Sheet 1:		
1-2		Burial Number
3		Sex:
	1	Male
	2	Female
	3	Subadult, sex unknown
	4	Adult, sex unknown
4-5		Age interval:
	01	0-0.9
	02	1.0-9.9
	03	10.0-19.9
	04	20.0-29.9
	05	30.0-39.9
	06	40.0-49.9
	07	50+
	99	Adult, age indeterminate
6-80		Specimen:
6-10		Calvarium
11-15		Bones of the face (except maxillae)
16-20		Maxilla
21-25		Mandible
26-30		Right Scapula
31-35		Left Scapula
36-40		Right Clavicle
41-45		Left Clavicle
46-50		Sternum
51-55		Ribs
56-60		Right Humerus
61-65		Left Humerus
66-70		Right Radius
71-75		Left Radius
76-80		Right Ulna
Sheet 2:		
1-2		Burial Number
4-78		Specimen:
4-8		Left Ulna
9-13		Right Hand

Column	Code	Description
Sheet 2 (continued):		
14-18		Left Hand
19-23		Right Innominate
24-28		Left Innominate
29-33		Right Femur
34-38		Left Femur
39-43		Right Tibia
44-48		Left Tibia
49-53		Right Fibula
54-58		Left Fibula
59-63		Right Patella
64-68		Left Patella
69-73		Right Foot
74-78		Left Foot
Sheet 3:		
1-2		Burial Number
4-23		Specimen:
4-8		Cervical Vertebrae
9-13		Thoracic Vertebrae
14-18		Lumbar Vertebrae
19-23		Sacrum

Types of Pathologies Investigated:

Code	Description
	Trauma:
11	Fracture
12	Crushing Injury
13	Dislocation
14	Wound Caused by Sharp Instrument
15	Other Types of Trauma
	Infectious Diseases:
21	Osteomyelitis
22	Primary Periostitis
23	Other Infectious Diseases
	Hemopoietic Disorders (Anemias):
31	Porotic Hyperostosis
32	Cribra Orbitalia
	Metabolic Disorders:
41	Osteomalacia
42	Rickets

Column	Code	Description
		Congenital and Developmental Defects:
	51	Vertebral Fusions
	52	Radio-Ulnar Synostosis
	53	Neural Arch Defect
		Tumors and Tumor-like Processes:
	61	Solitary Bone Cyst
	62	Exostosis
	63	Other
	71	Degenerative Arthritis
		Dental Disease:
	81	Abscess
	82	Antemortum Tooth Loss
	83	Carious Lesion

		Pathological State:
	01	Active
	02	Healing
	03	Healed
		Location of Pathology:
	1	Diaphysis
	2	Metaphysis
	3	Epiphysis
	4	Articular Joint
	5	Vertebral Body
	6	Vertebral Transverse Process
	7	Vertebral Spinous Process
	9	Other

NOTE: Each bone has a five-space description in which the first two spaces denote the "type of pathology", the third and fourth spaces, the pathological state, and the fifth space denotes the location of the pathology on the particular specimen. For example: if a right radius is coded "11031", this signifies the presence of a healed fracture on the diaphysis of the bone.

<u>Definitions of Pathological Conditions</u>:

1. <u>Fracture</u>: includes conventional discontinuities of bone as well as cases of bone wounds caused by sharp objects (projectile points embedded in bone, trephination, scalping, etc.), compression fractures of vertebrae and pseudarthrosis, or nonunion (Ortner and Putschar 1981:72-85).

2. <u>Crushing Injuries</u>: fractures caused by a fall or by a blow from a heavy object (Steinbock 1976:24).

3. <u>Dislocation</u>: displaced bones from their normal position in a joint resulting in the formation of a new articular joint surface (Ortner and Putschar 1981:85-90).

4. <u>Osteomyelitis</u>: inflammation of the marrow cavity characterized by cortex destruction with subperiosteal bone apposition and sequestra and abscess formation (Steinbock 1976:68).

5. <u>Primary Periostitis</u>: inflammation of the periosteum characterized by periosteal reactive bone superficial to the underlying cortex and the absence of cloacae, involucrum or changes in the marrow cavity (Ortner and Putschar 1981:132-133).

6. <u>Porotic Hyperostosis</u>: thickening of the cranial diploe causing thinning and destruction of the outer table of the cranial vault on which the affected area takes on a sieve-like or coral appearance (Steinbock 1976: 214).

7. <u>Cribra Orbitalia</u>: bilateral pitting on the superior surfaces of the orbits (Steinbock 1976:213).

8. <u>Osteomalacia</u>: adult form of rickets, see below.

9. <u>Rickets</u>: bending deformities especially in the weight-bearing areas; bowlegs, chest deformities, contracted pelvis, collapsed vertebra, porotic bone deposition of the cranial vault, and possible widening of the long bone metaphyses (Morse 1969:27; Ortner and Putschar 1981:274-283).

10. <u>Vertebral Fusions</u>: fusion of the atlas to the occipital bone (Morse 1969:31, 90).

11. <u>Radio-ulnar Synostosis</u>: fused proximal ends of the ulna and radius (Morse 1969:33).

12. <u>Neural Arch Defects</u>: includes spina bifida (incomplete closure of the spinous process of the sacrum), and spondylolysis, separation of the neural arch from one or more vertebrae (Ortner and Putschar 1981:358).

13. <u>Solitary Bone Cyst</u>: a hole or defect in the bone caused by bone resorption; may be lined with a thin layer of cortical bone and some localized widening may occur (Morse 1969:22).

14. <u>Exostosis</u>: bony spurs usually found in the external auditory canal (Morse 1969:21).

15. <u>Degenerative Arthritis</u>: alteration of articular joints expressed either by rarefaction--porosity, osteophytosis--marginal lipping, or eburnation--hardening and polishing of the joint surface, or by a combination thereof (Ubelaker 1978:78).

16. <u>Abscess</u>: cavity in the bone in the vicinity of the root of a tooth (Ortner and Putschar 1981:455).

17. <u>Antemortum Tooth Loss</u>: absence of a tooth with alveolar resorption (Morse 1969:132-134).

18. <u>Carious Lesion</u>: penetrating hole in the enamel of the interproximal or occlusal surface of a tooth, possibly spreading into the dentin (Ortner and Putschar 1981:438-442).

VITA

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